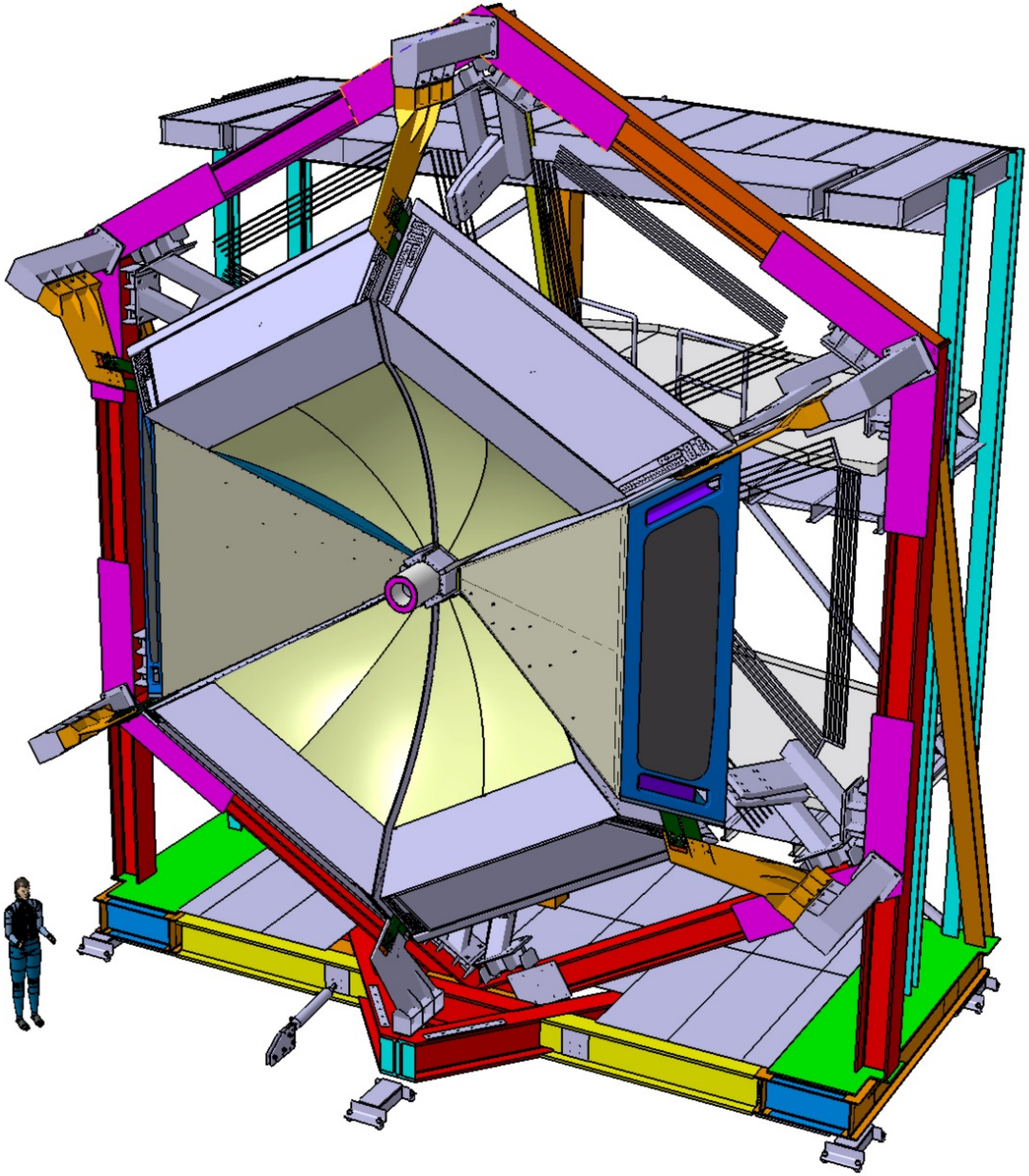


CLAS12-RICH Project-Overview

June 24th 2015

The CLAS12 Spectrometer

Ongoing upgrade of the CLAS detector.
First beam expected in 2016.

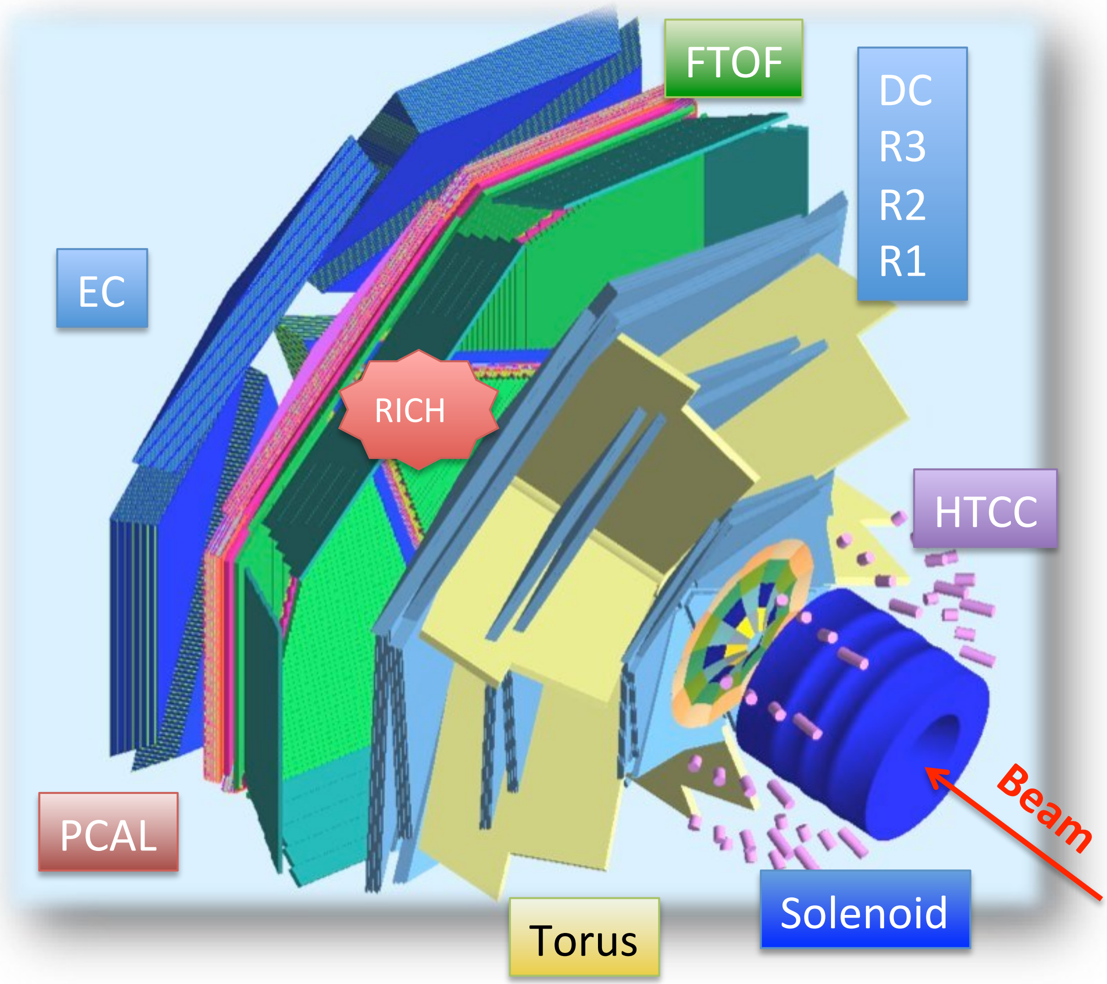
Highly polarized 12 GeV electron beam

Luminosity up to 10^{35} cm^{-2} s^{-1}

H and D polarized targets

Broad kinematic range coverage
(current to target fragmentation)

RICH: Hadron ID
for flavor separation
(common to >3 SIDIS approved exp.)



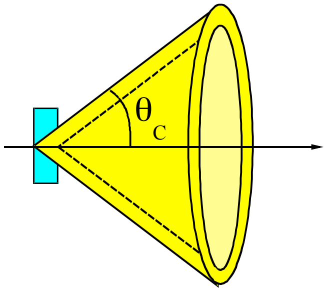
PAC30 report (2006): Measuring the kaon asymmetries is likely to be as important as pions …. The present capabilities of the present CLAS12 design are weak in this respect and should be strengthened.

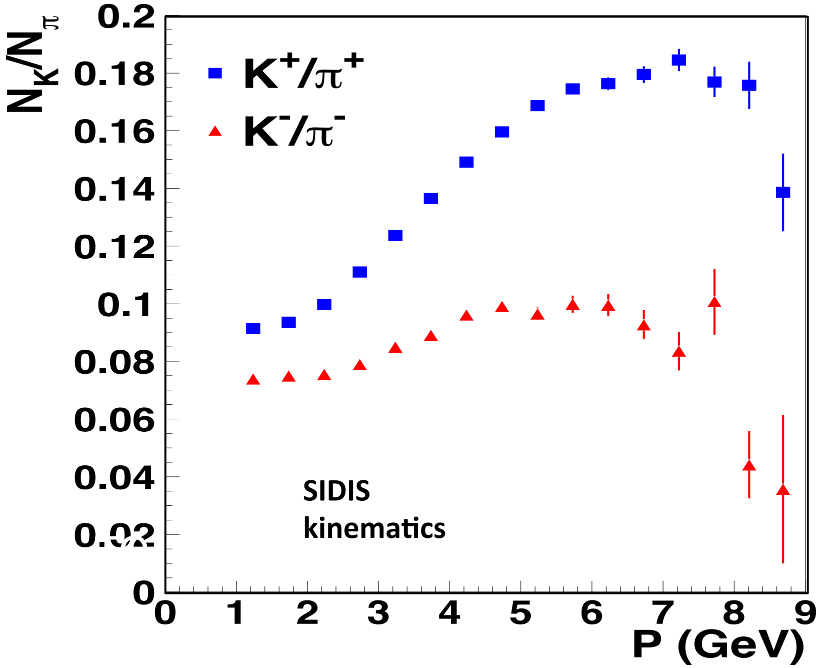
CLAS12 Momentum Range

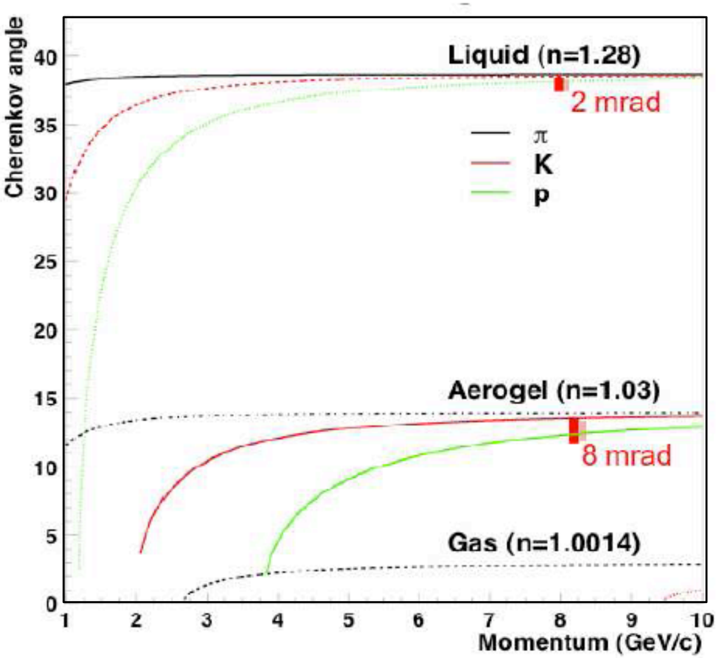
- Kaon flux 1 order of magnitude lower than π → **π rejection 1:500 required**
- **Aerogel** mandatory to separate hadrons in the 3-8 GeV/c momentum range with the required large rejection factors

  → collection of **visible Cherenkov light**

- **Use of PMTs:** challenging project, need to minimize the detector area covered with expensive photo-detectors

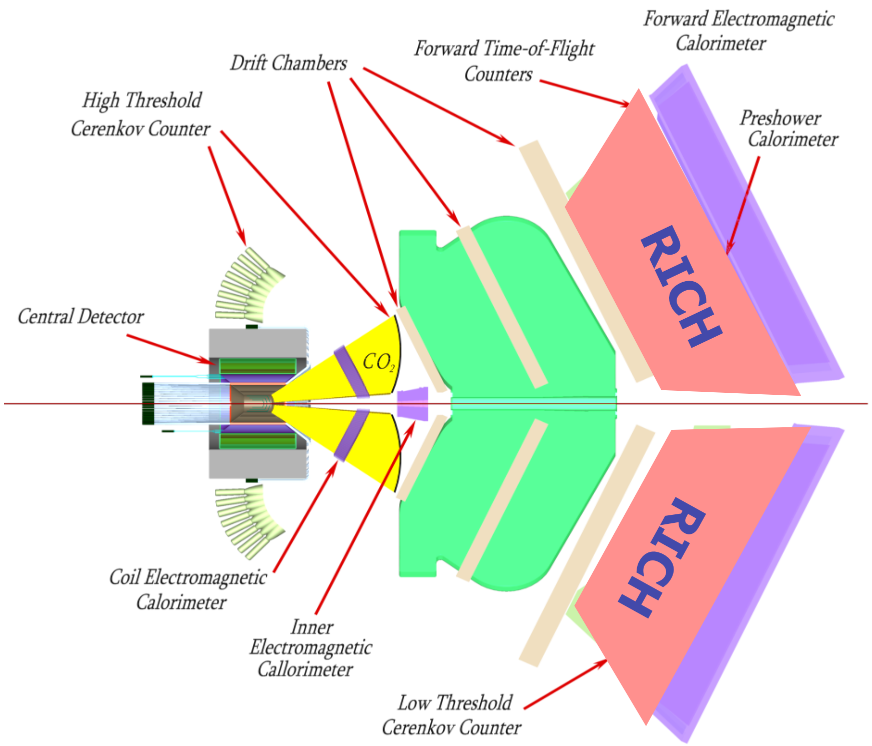






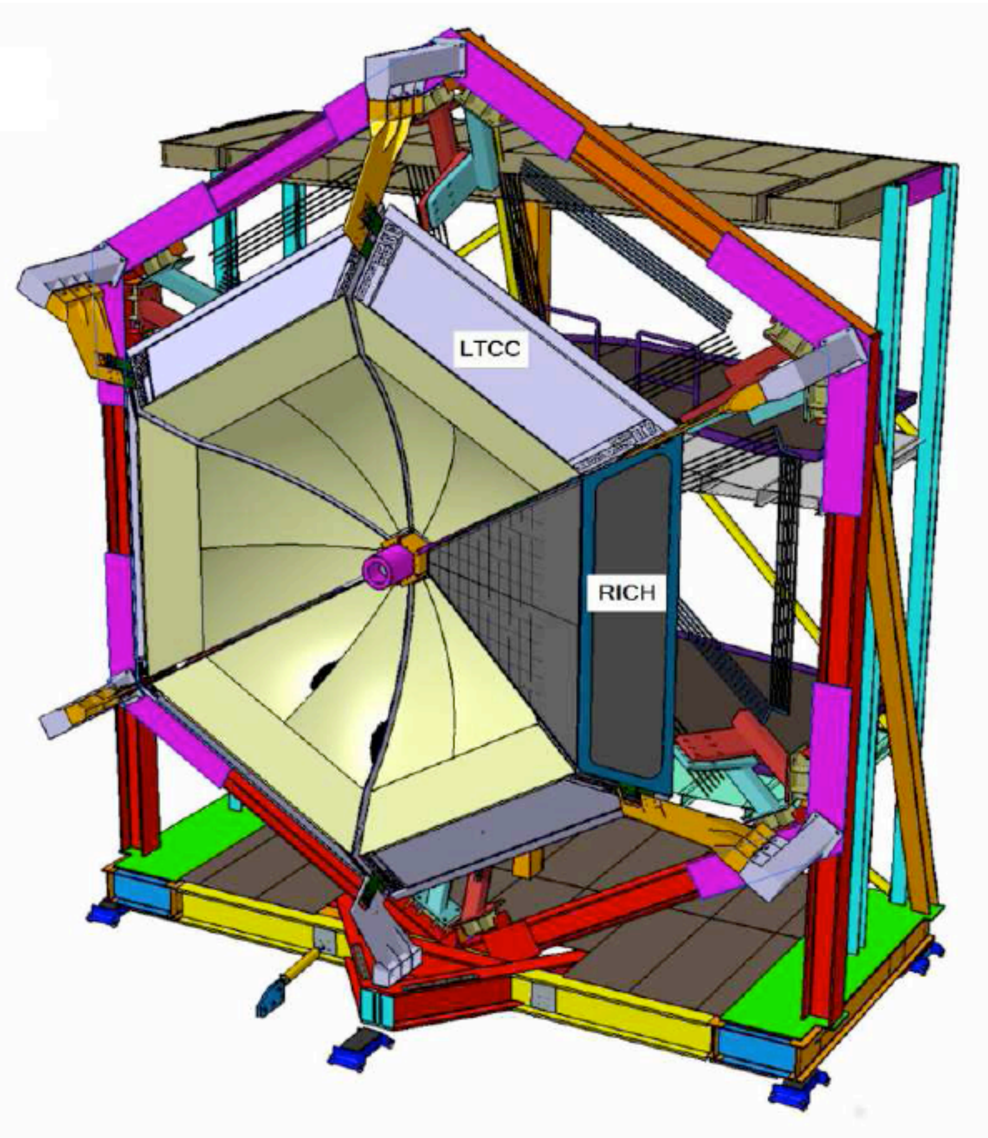
The CLAS12 RICH Project

RICH goal: **π/K/p identification from 3 up to 8 GeV/c and 25 degrees**
~4σ pion-kaon separation for a pion rejection factor ~ 1:500



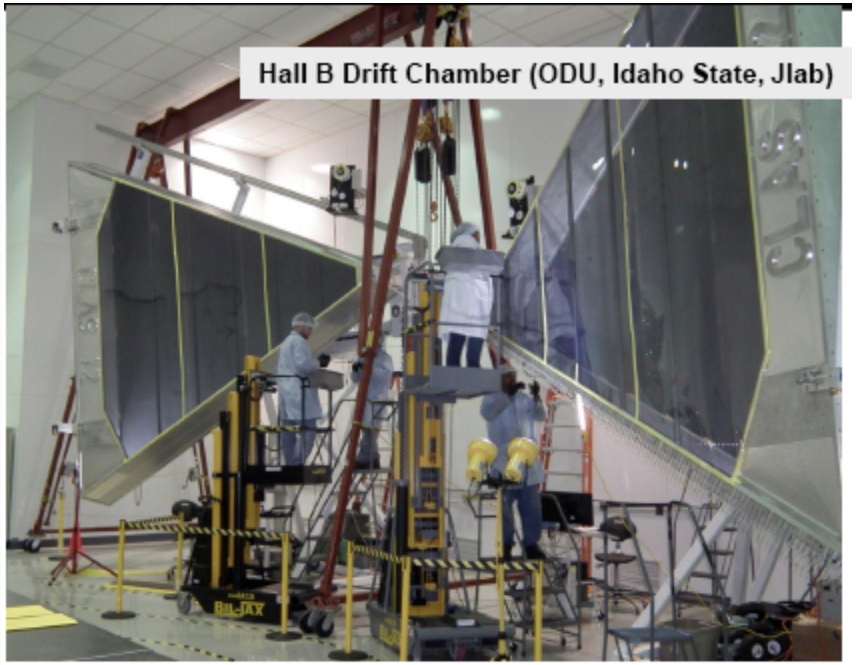
INSTITUTIONS
INFN (Italy) Bari, Ferrara, Genova, L.Frascati, Roma/ISS
Jefferson Lab (Newport News, USA)
Argonne National Lab (Argonne, USA)
Duquesne University (Pittsburgh, USA)
Glasgow University (Glasgow, UK)
J. Gutenberg Universitat Mainz (Mainz, Germany)
Kyungpook National University, (Daegu, Korea)
University of Connecticut (Storrs, USA)
UTFSM (Valparaiso, Chile)

Base Configuration



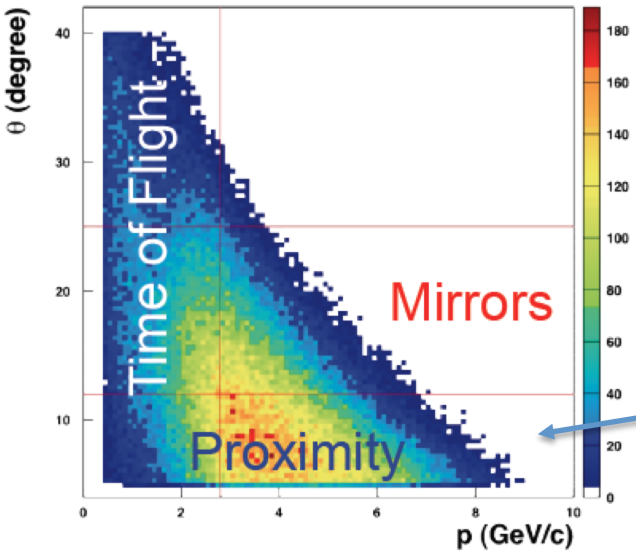
1st sector in time for physics run
(unpolarized and longitudinal polarize targets)

Crucial for the study of parton dynamics related to angular momentum and spin-orbit effects with flavor sensitivity.

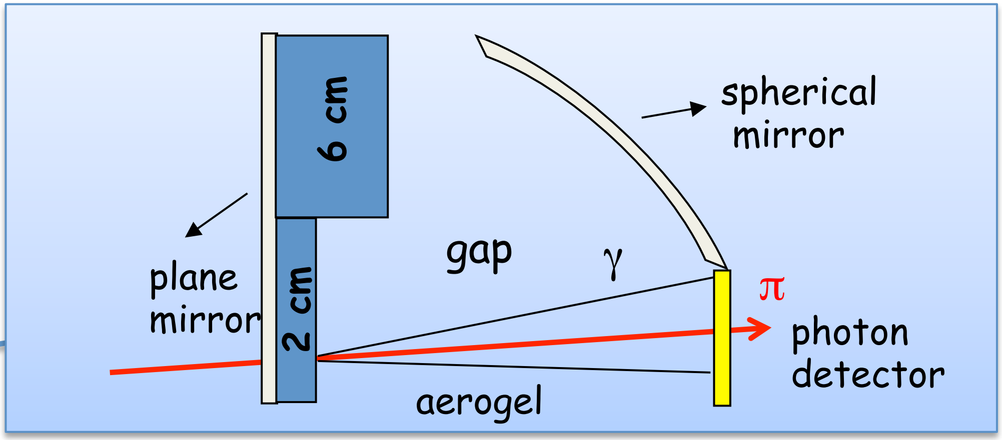


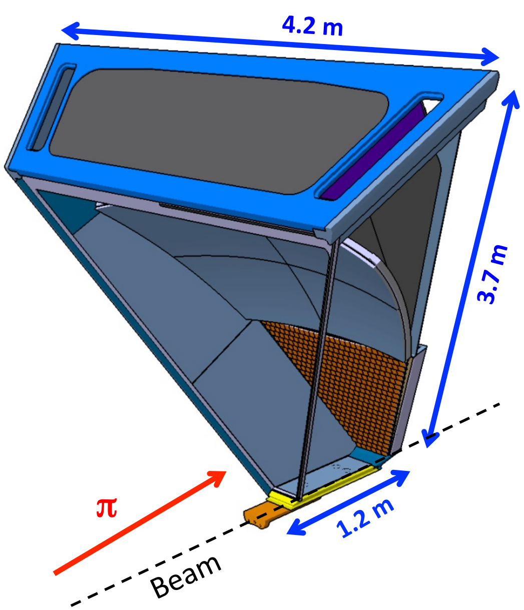
2nd++ sector for transverse target
(left-right symmetry and statistics)

The Hybrid Optics Design

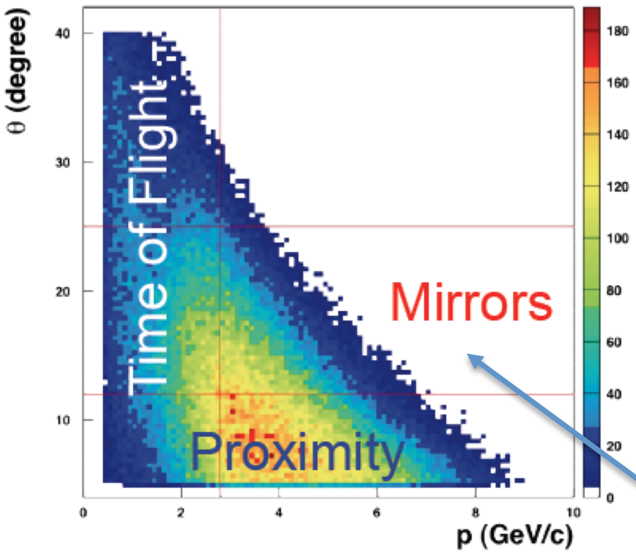


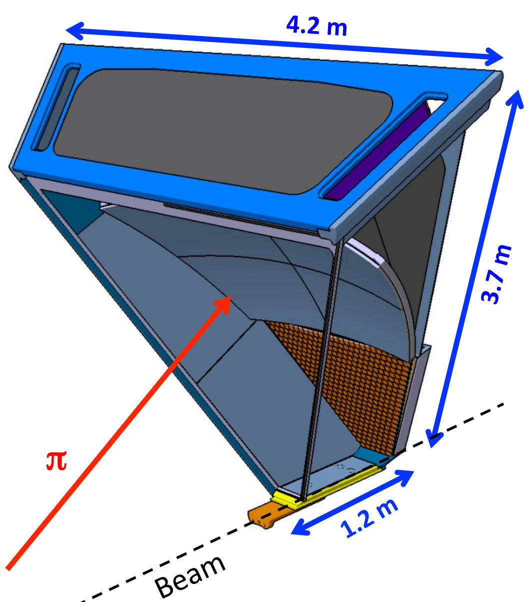
Direct rings and best performance for high momentum particles



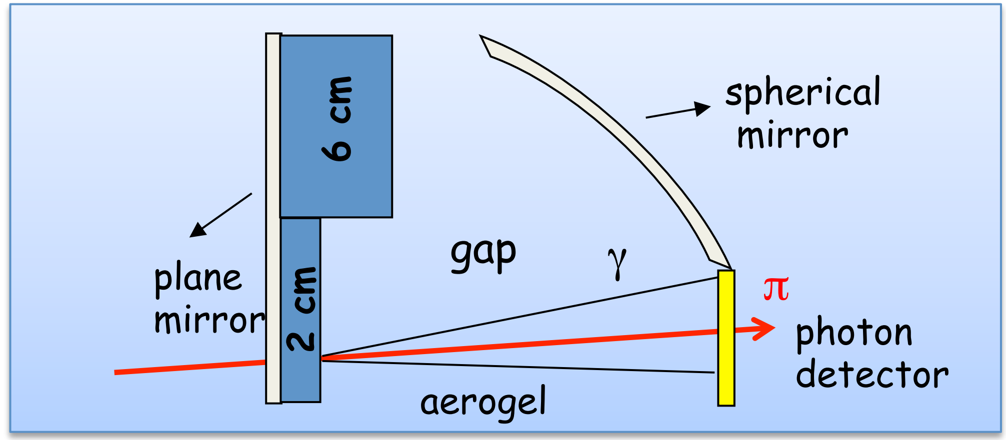


The Hybrid Optics Design

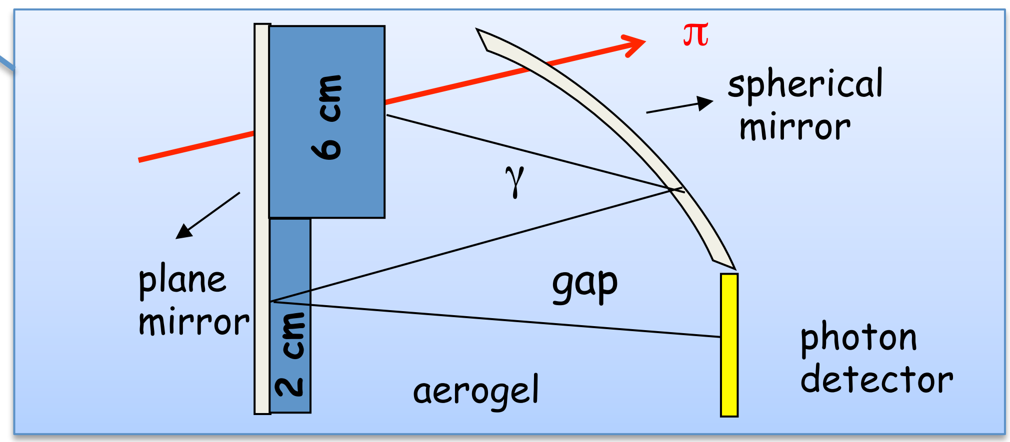




Direct rings and best performance for high momentum particles

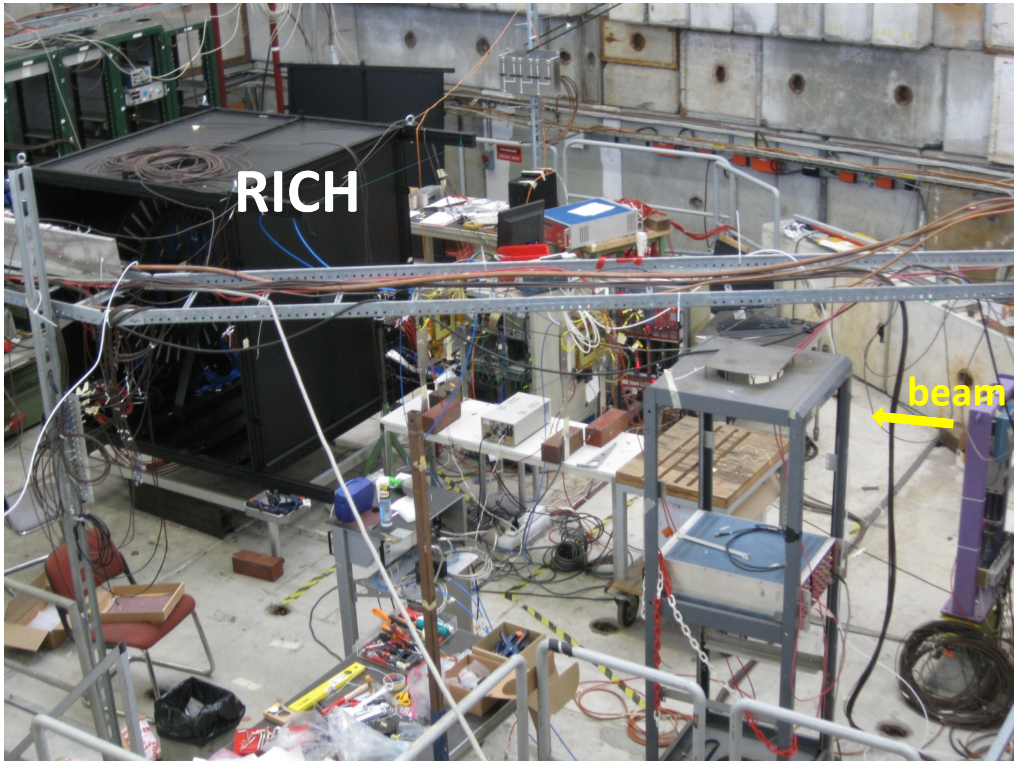


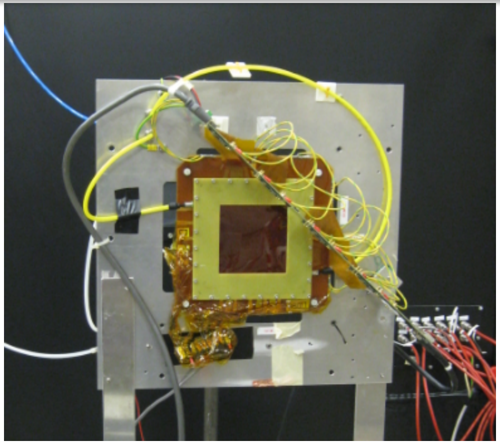
Reflected rings for less demanding low momentum particles



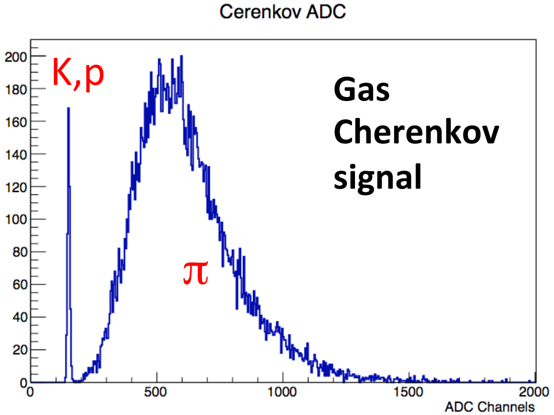
- Minimize active area (cost) to about 1 m^2
- Material budget concentrated where TOF is less effective
- Focalizing mirrors allow thick radiator for good light yield
- Time resolution < 1 ns to distinguish direct and reflected patterns

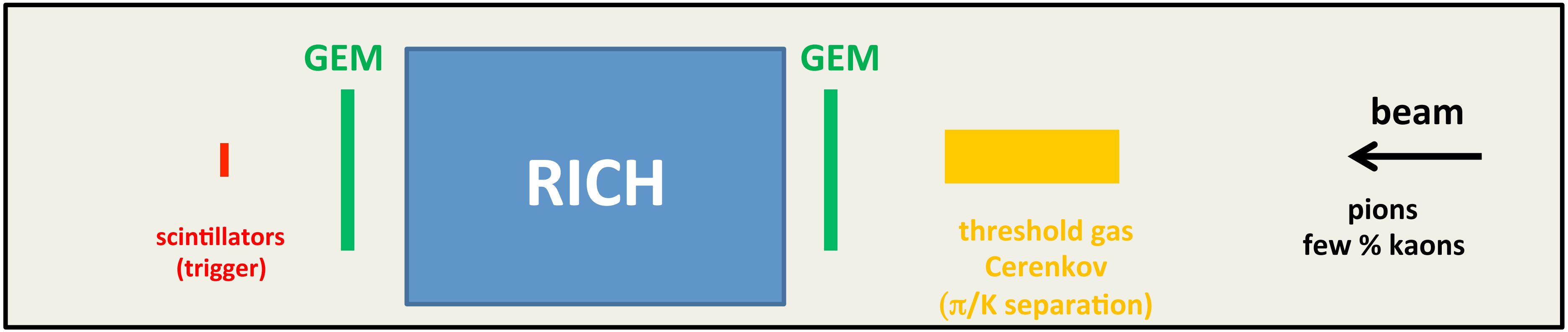
RICH Prototype at CERN-T9





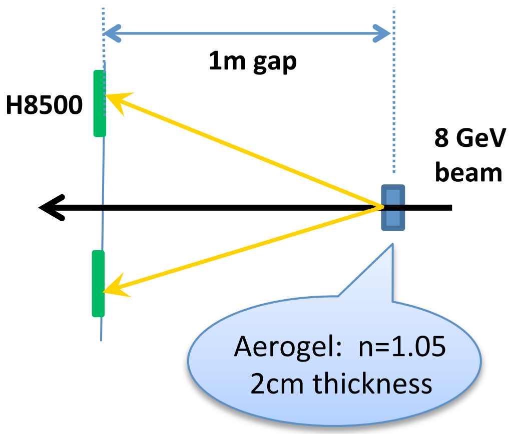
GEM chamber layout

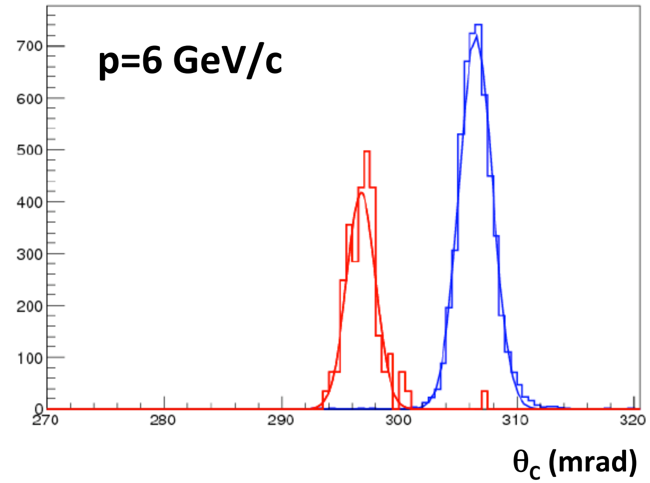


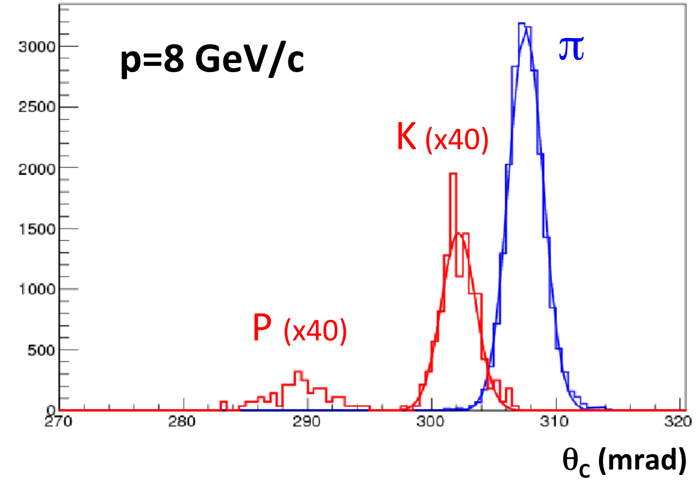


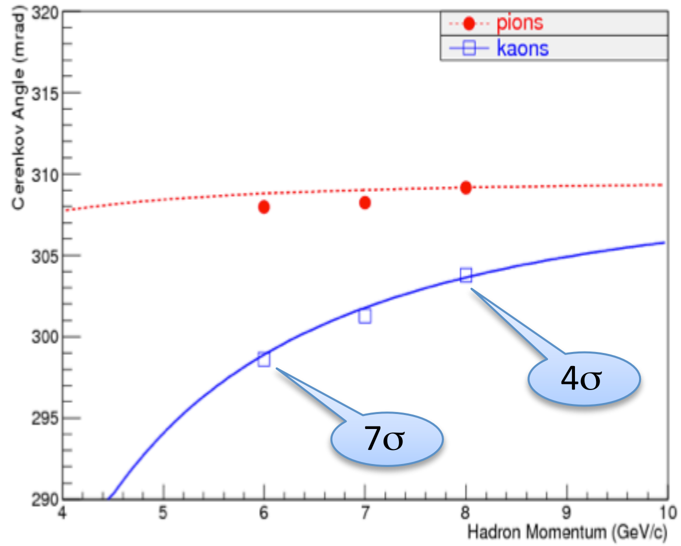
RHIC Prototype: Direct Light Case

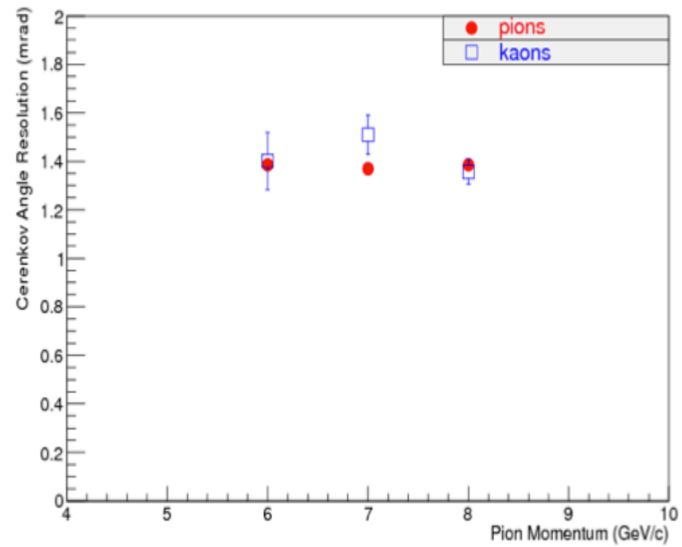
Clear hadron separation up to the CLAS12 maximum momentum



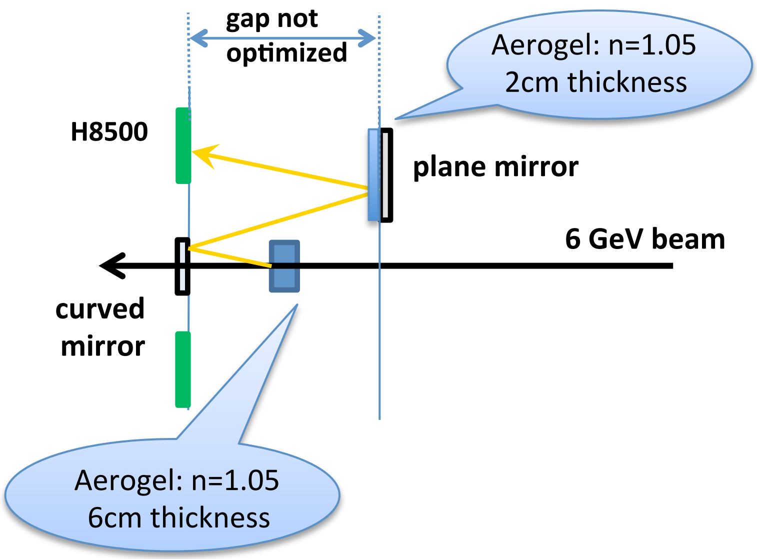




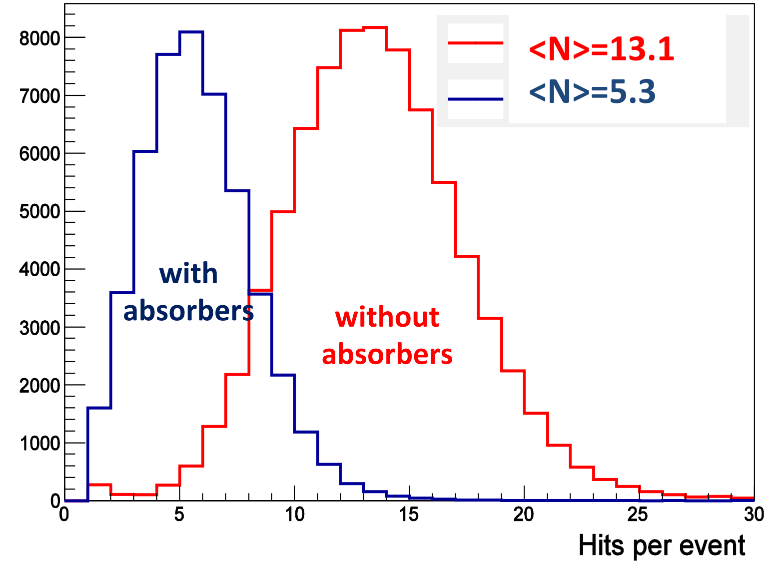


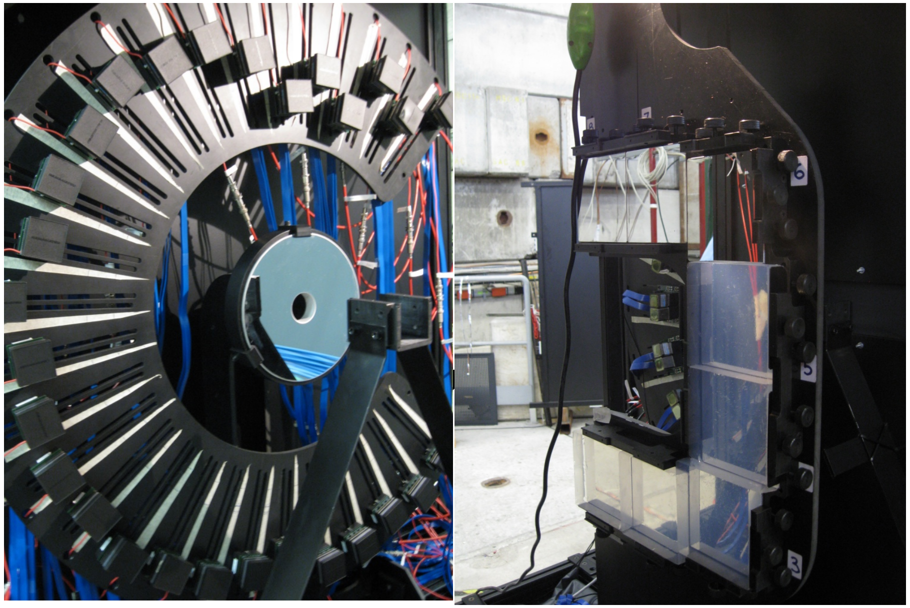


RHIC Prototype: Reflected Light Case

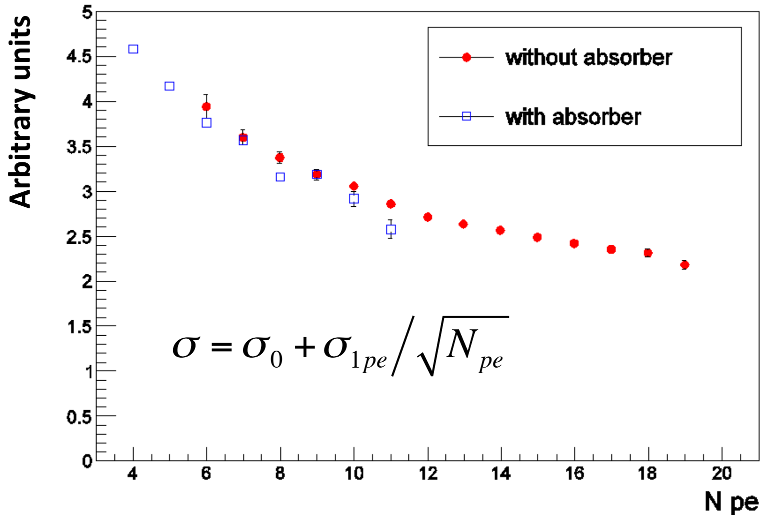


With absorbers: sizeable fraction of light survives





and resolution is not significantly degraded



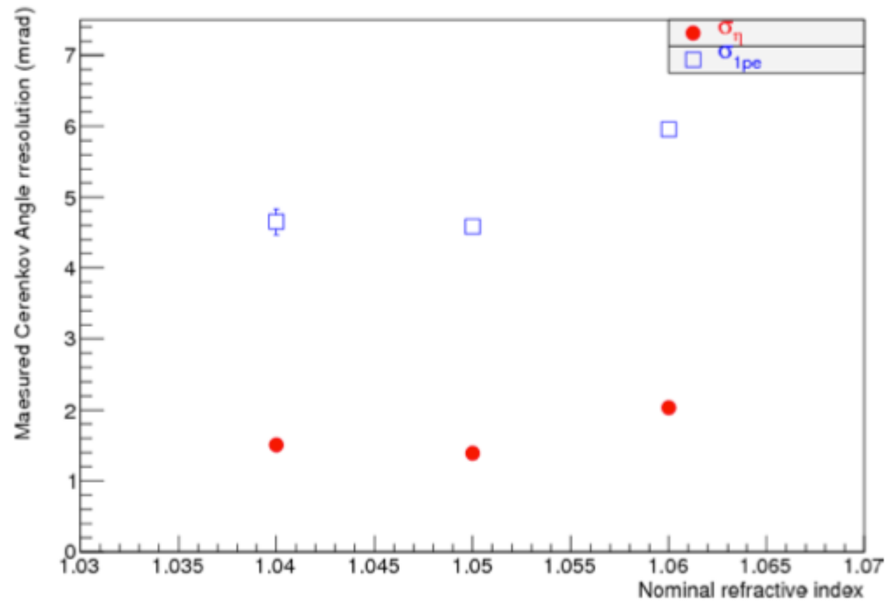
CLAS12 RHIC: Resolution

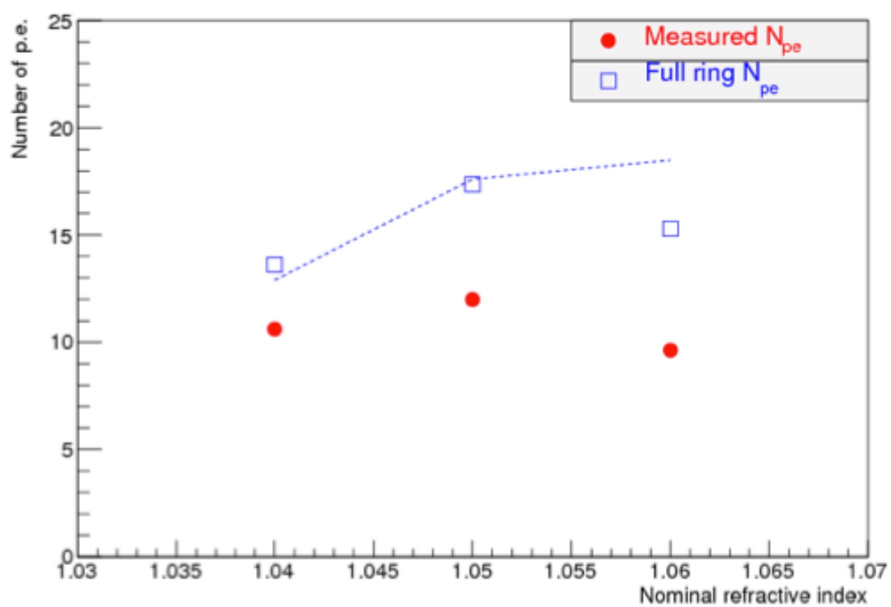
Resolution	Direct (mrad)	Reflected (mrad)
Emission Point	1.7	1.7
Readout Accuracy	2.1	1.0
Chromatic Aberration	3.0	2.5
Aerogel Optical Prop.	≤ 1	≤ 2
Mirror System		≤ 1
σ_θ (1 p.e.)	4.2	3.9
Requirements	**Direct**	**Reflected**
Max. momentum	8 GeV/c	6 GeV/c
σ_θ (4σ separation)	1.4 mrad	2.5 mrad
Np.e. Yield	≥ 10	≥ 3

$$\sigma_{\vartheta_{Ch}} = \sqrt{\sum_i \frac{\left(\sigma^i_{\vartheta_{Ch}}\right)^2}{N_{p.e.}}}$$

RHIC Prototype: Direct Light Case

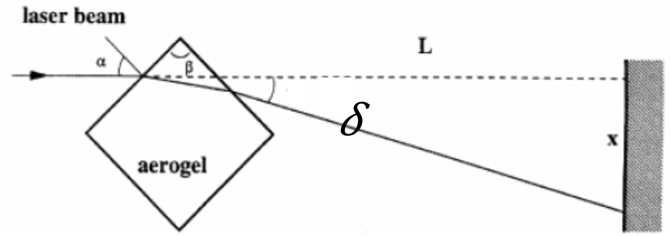
Resolution	Direct (mrad)
Emission Point	1.7
Readout Accuracy	2.1
Chromatic Aberration	3.0
Aerogel Optical Prop.	≤ 1
Mirror System	
σ_θ (1 p.e.)	4.2
Requirements	**Direct**
Max. momentum	8 GeV/c
σ_θ (4σ separation)	1.4 mrad
Np.e. Yield	≥ 10

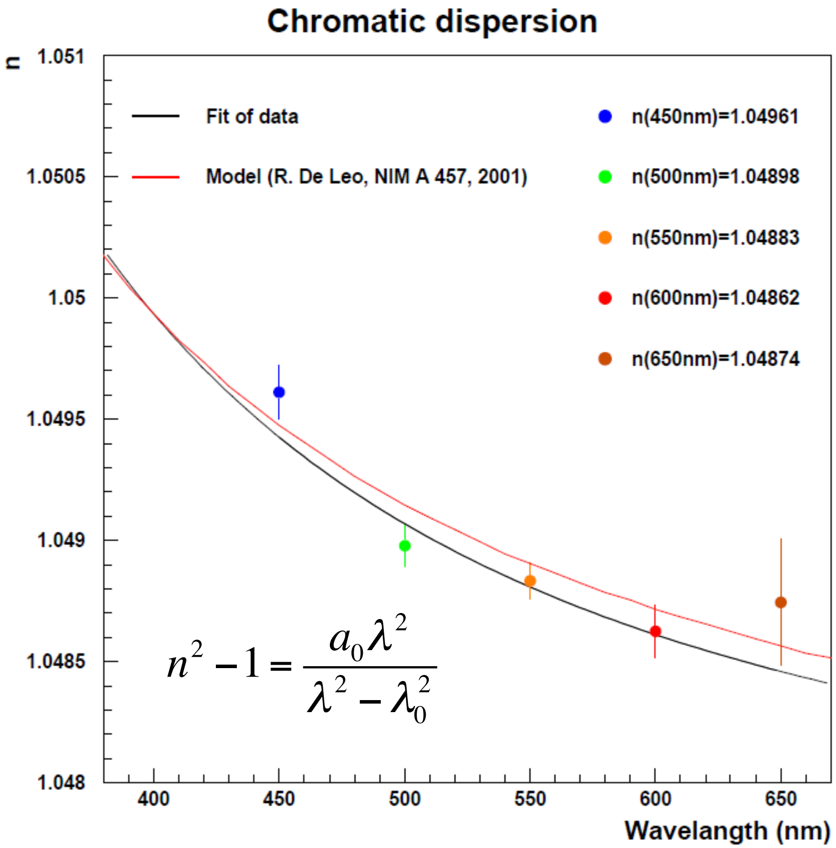




Aerogel Chromatic Dispersion

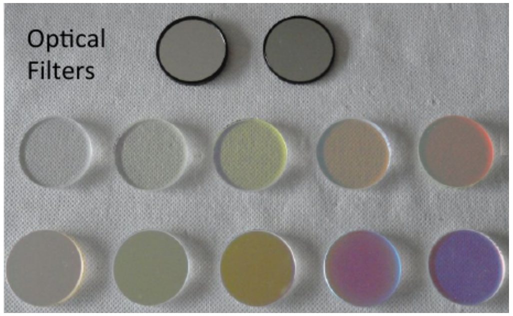
Measured by prisma method:

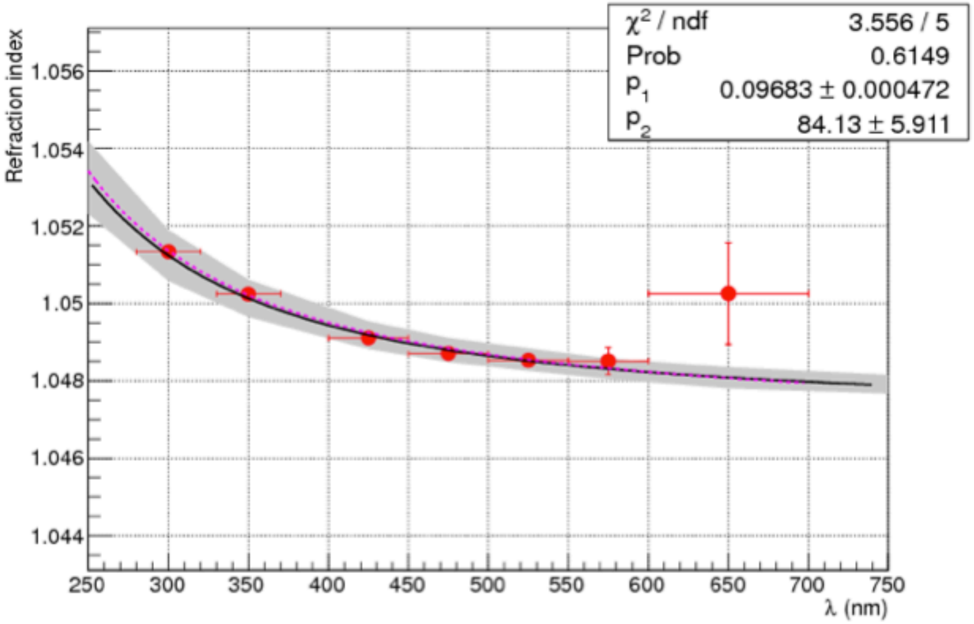




$$n^2 - 1 = \frac{a_0 \lambda^2}{\lambda^2 - \lambda_0^2}$$

Measured by prototype with optical filters:





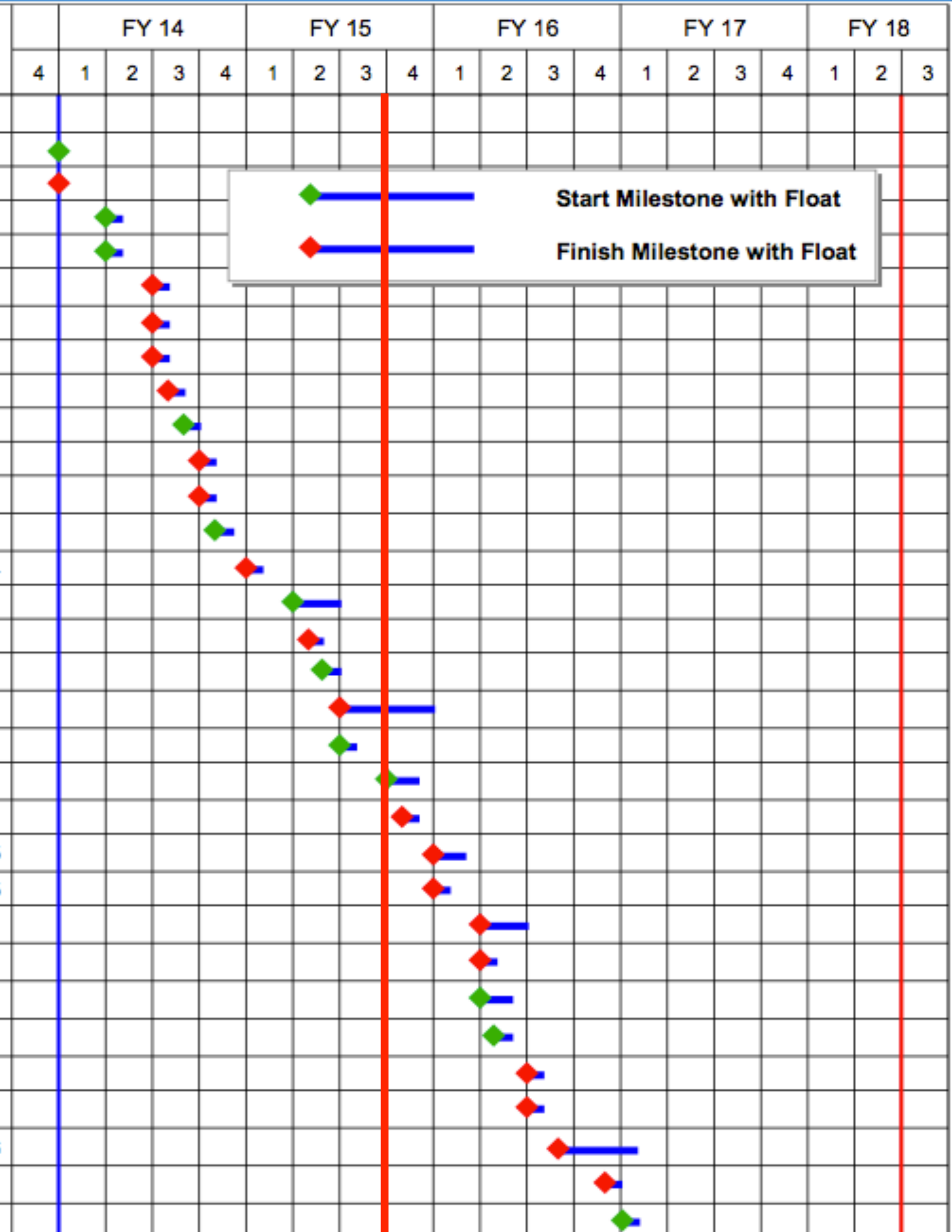
Expected value from density:

$n^2(400nm) = 1+0.438\rho$

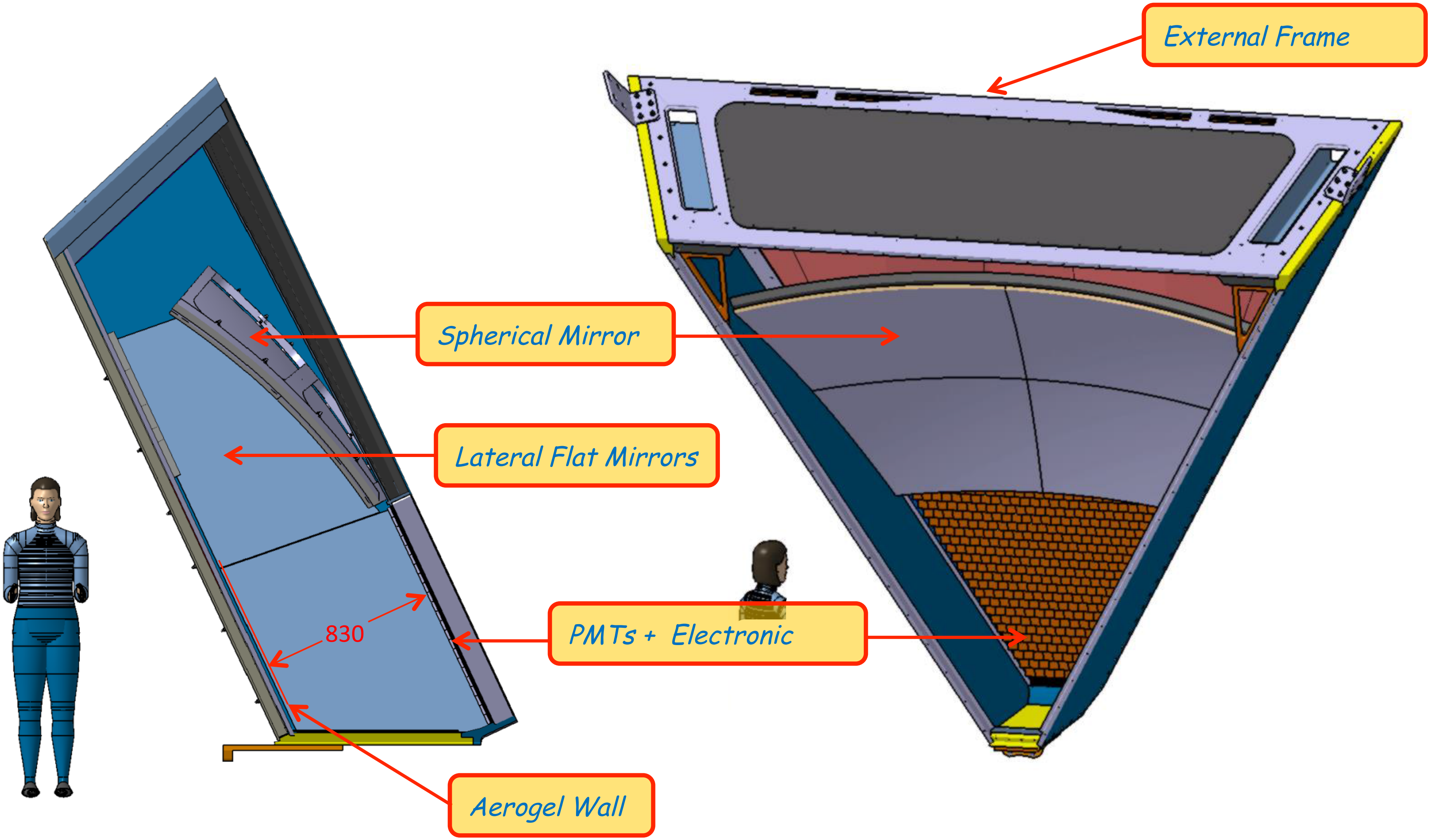
$n(400nm) = 1.0492$

RICH Project Milestones

Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16



RICH Assembling



RICH Project: Aerogel

Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16

Initial delay due to lack of chemicals

25 % ready for delivery

Aerogel Production

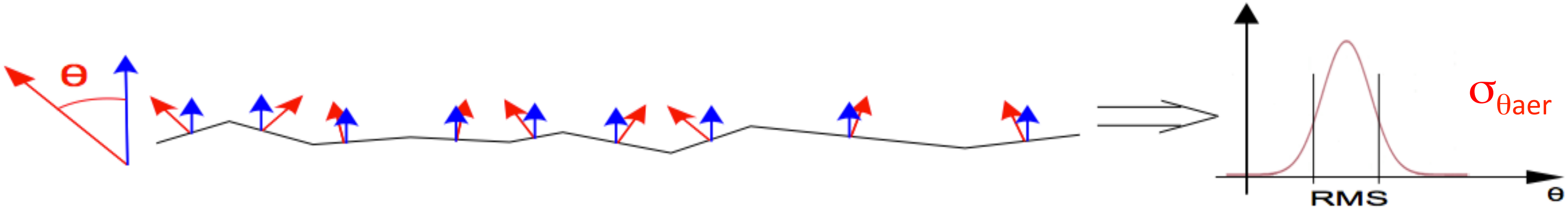
Критерий отбора:

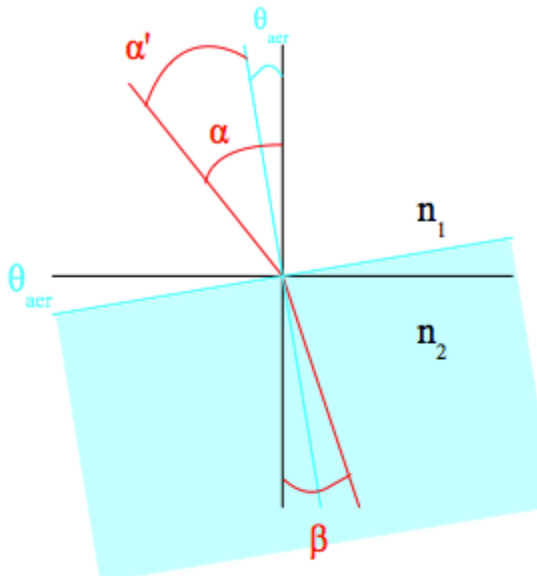
$L_{sc} > 43$; $A_0 > 0.95$; $1.048 < n < 1.052$ {$0.224 < \rho < 0.244$} $n^2 = 1 + 0.438\rho$

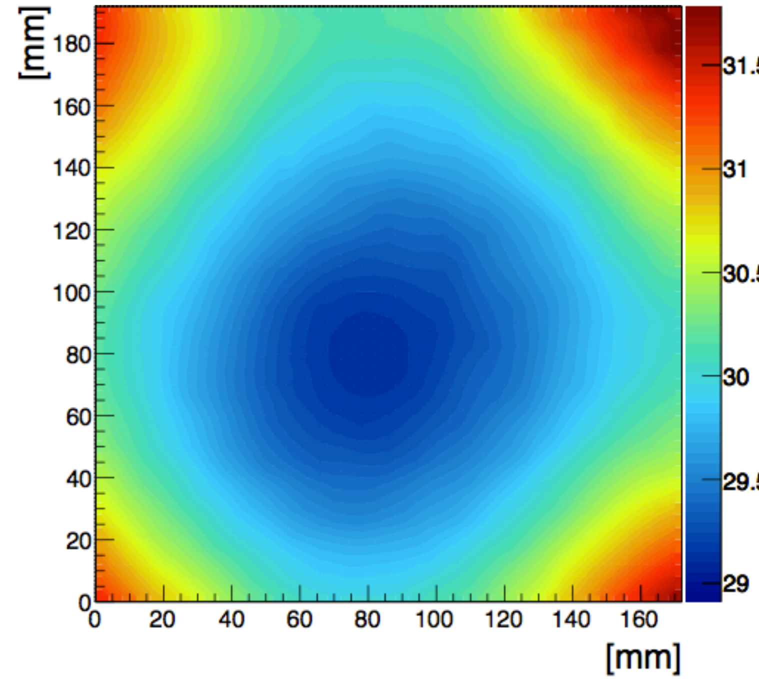
№	Experiment	Density ρ, g/cm^3	Scattering length L_{sc}, mm	A_0, %	Date of measurement (L_{sc})	Kp ±0.2
1	оп397ф15	0.237	49.56±0.79	99.04±0.4	19.12.14	1.7
2	оп397ф16	0.233	47.67±1.19	97.77±0.9	23.12.14	1.5
3	оп397ф10	0.234	49.2±1.54	97.73±0.9	28.12.14	1.5
4	оп397ф	0.234	48.2±0.63	92.98±0.5	28.12.14	1.4
5	оп397ф33	0.237	51.32±1.28	98.91±0.6	29.12.14	1.5
6	оп398ф3	0.228	40.93±0.51	98.35±0.7	20.01.15	
7	оп397ф40	0.246	46.12±0.58	97.84±0.5	20.01.15	0.9
8	оп397ф9	0.241	46.87±0.8	96.66±0.4	20.01.15	1.5
9	оп398ф6	0.238	41.56±0.52	97.90±0.9	20.01.15	
10	оп398ф4	0.233	43.3±1.2	98.75±0.4	26.01.15	
11	оп398ф13	0.236	47.05±1.34	98.76±0.5	26.01.15	1.5
12	оп398ф31	0.237	51.28±1.31	99.54±0.5	04.02.15	1.7
13	оп398ф32	0.234	48.09±1.26	97.75±0.6	04.02.15	1.5

Aerogel Planarity < 1.5

Aerogel Surface







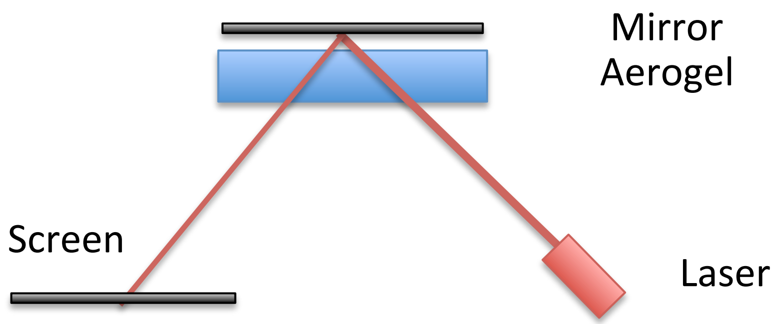
Refraction from a surface
with local normal deviation θ

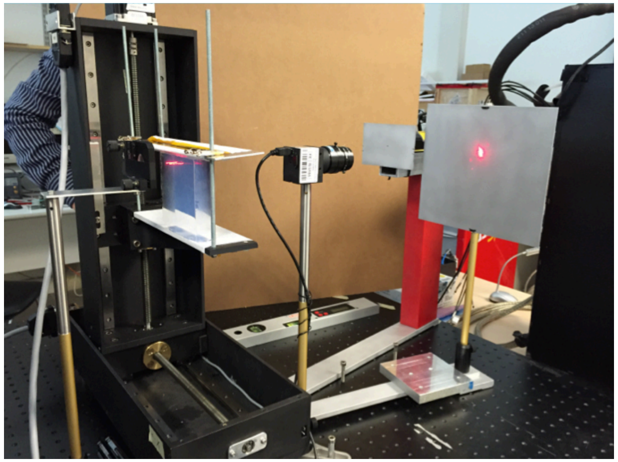
$$\beta = \vartheta_{aer} + \arcsin\left(\frac{1}{n}\sin(\alpha - \vartheta_{aer})\right)$$

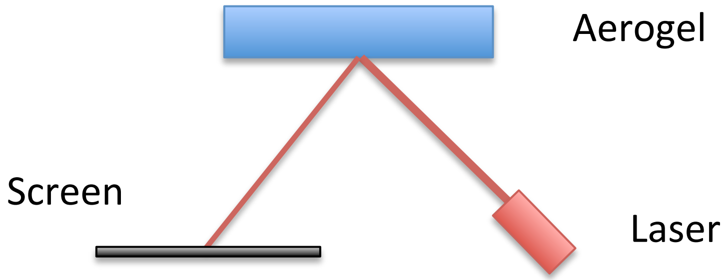
Contribution on light dispersion
at small incident angles

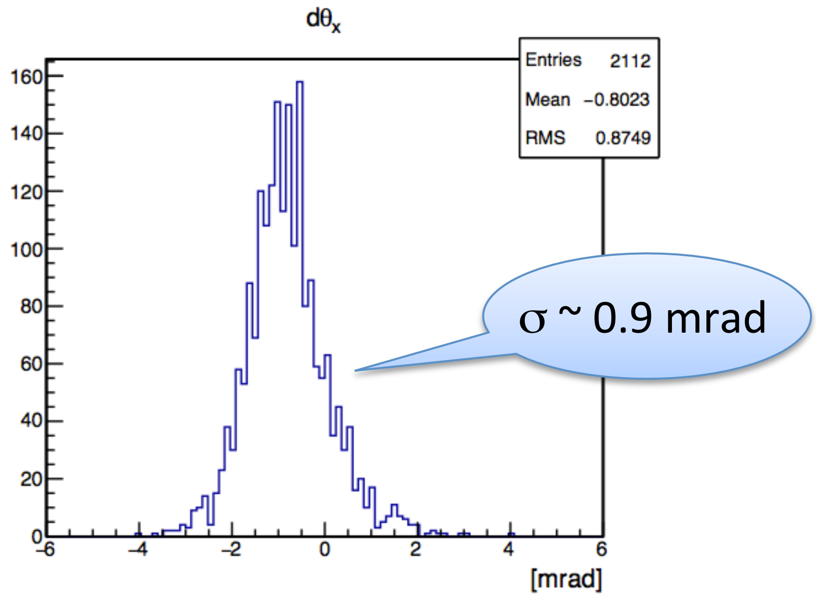
$$\sigma_{\vartheta_{light}} = \left(1 - \frac{1}{n}\right) \cdot \sigma_{\vartheta_{aer}} \approx 0.05 \cdot \sigma_{\vartheta_{aer}}$$

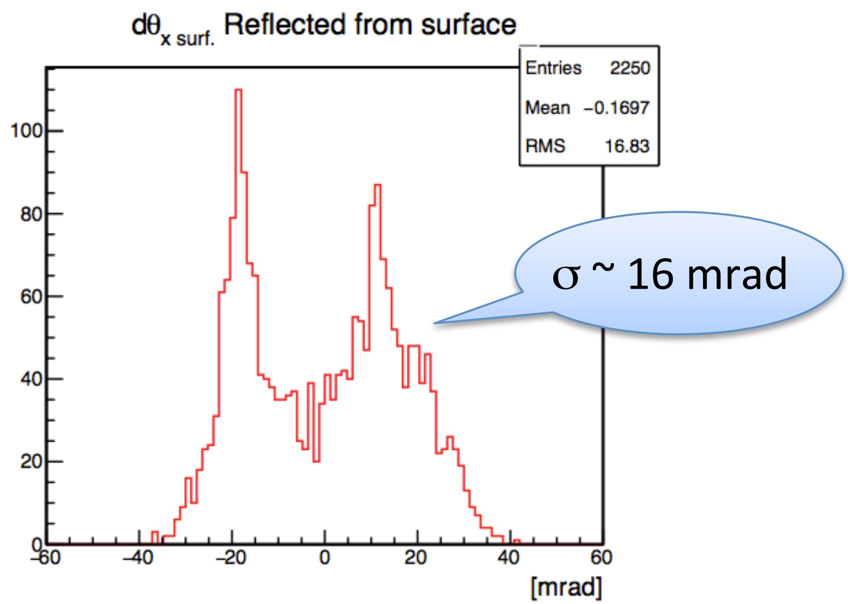
Aerogel Surface





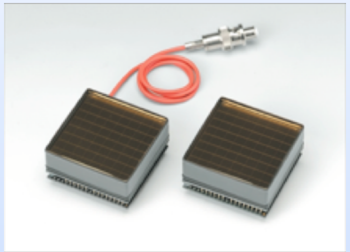






RICH Project: MA-PMTs

Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16



H8500 → H12700

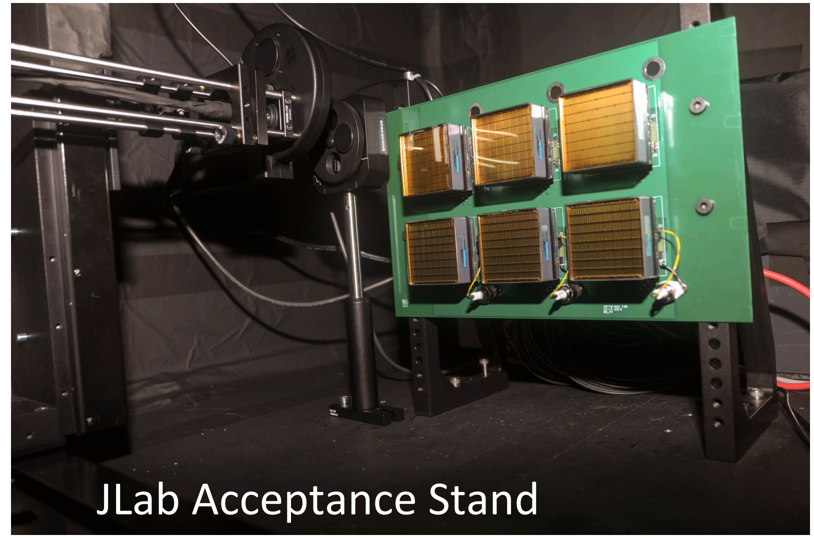
50 % in house

MA-PMT Photon Detector

110 Hamamatsu MAPMT out of 430 delivered and tested at JLab

- 80 H8500
- 110 H12700 with enhanced SPE spectrum

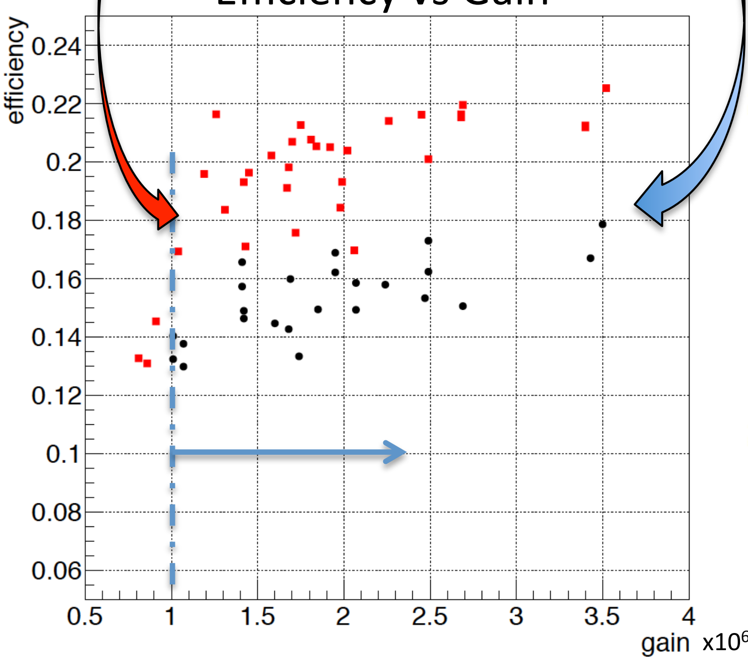
Procurement secured for new H12700 PMTs



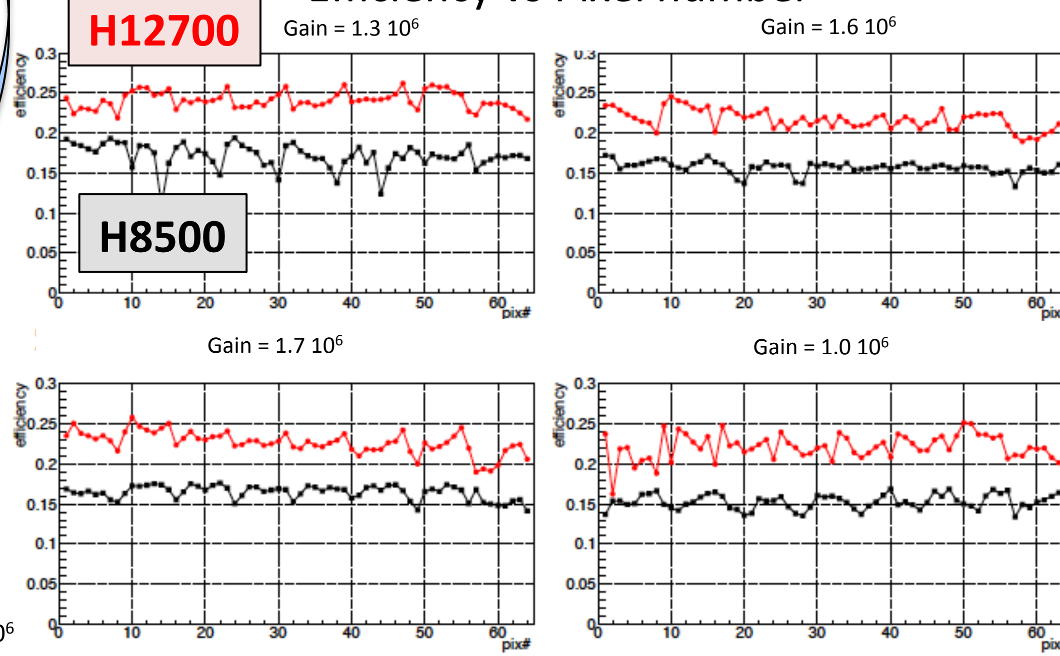
PMT Efficiency Comparison:

H12700 ⟷ H8500

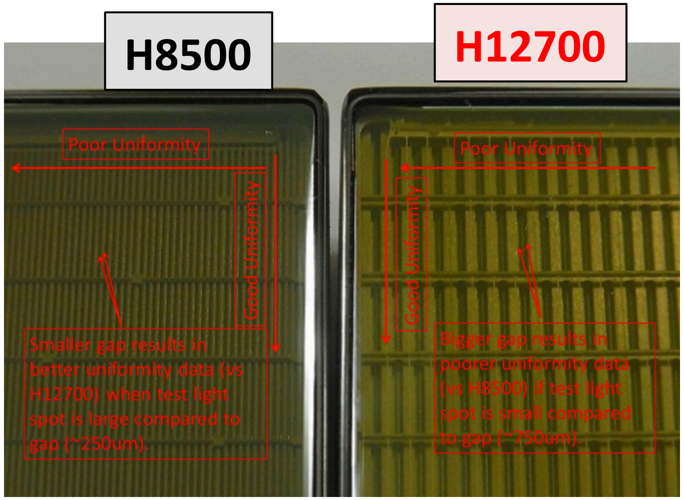
Efficiency vs Gain

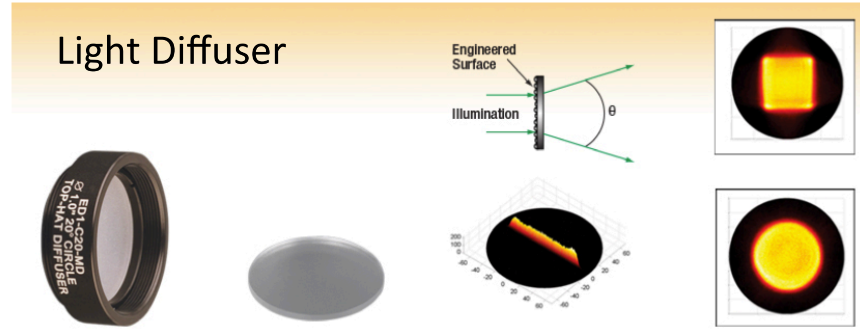


Efficiency vs Pixel number

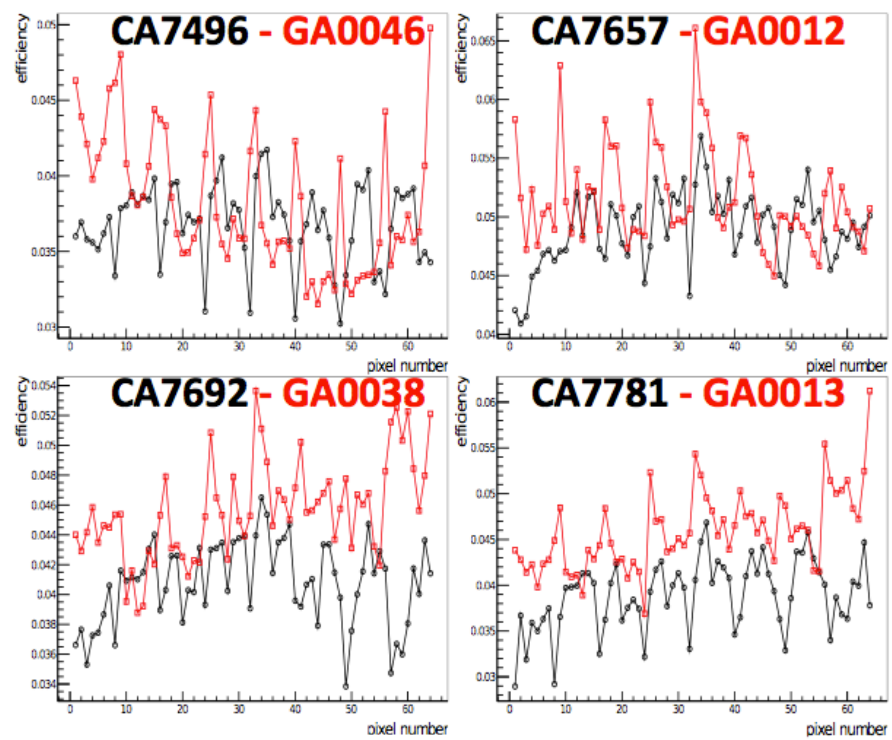


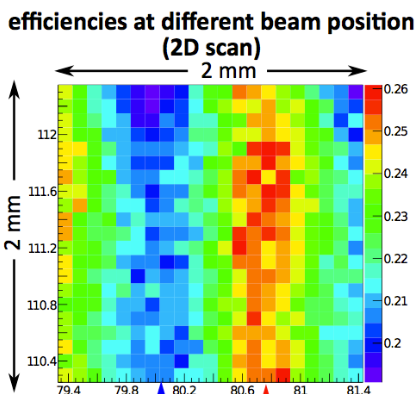
MA-PMT Photon Detector

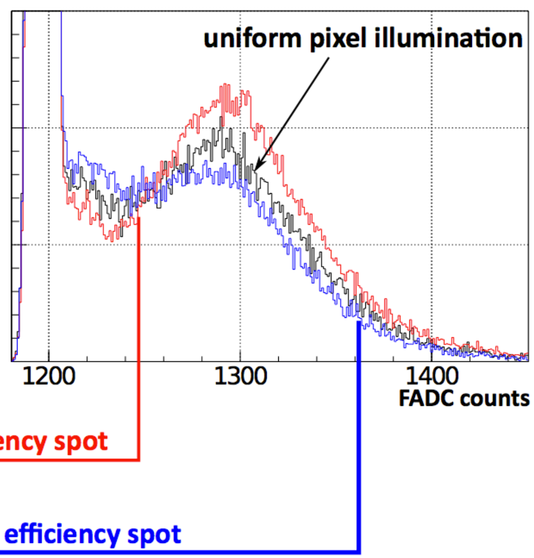




Efficiency with full pixel illuminated

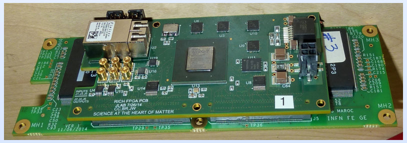






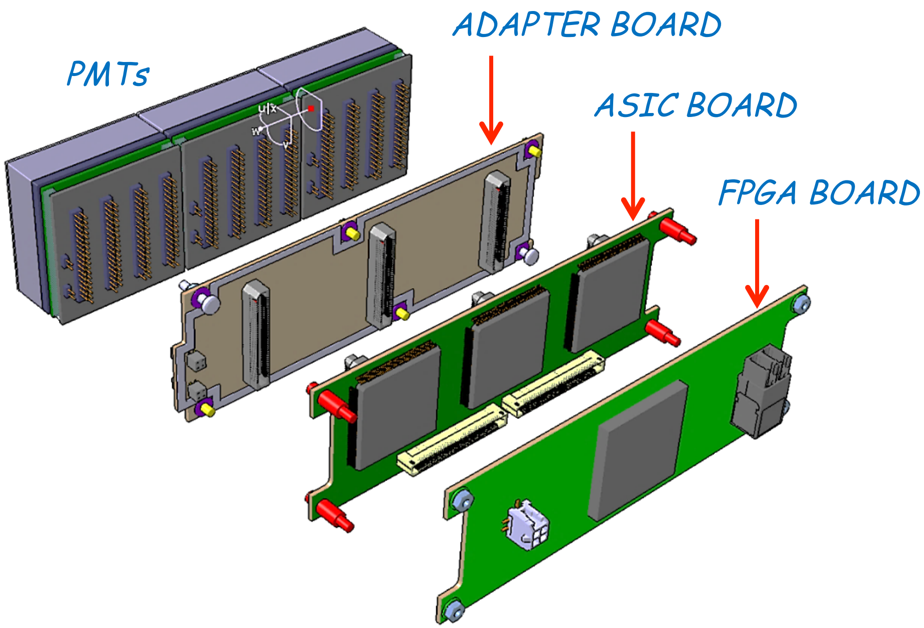
RICH Project: Electronics

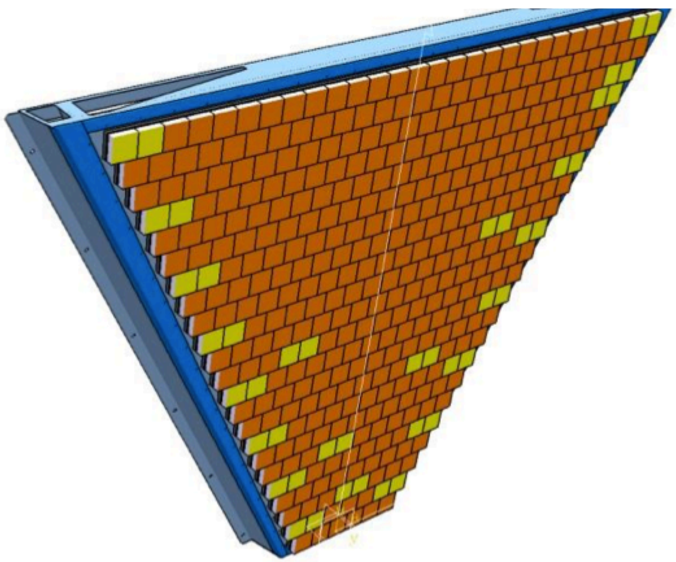
Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16



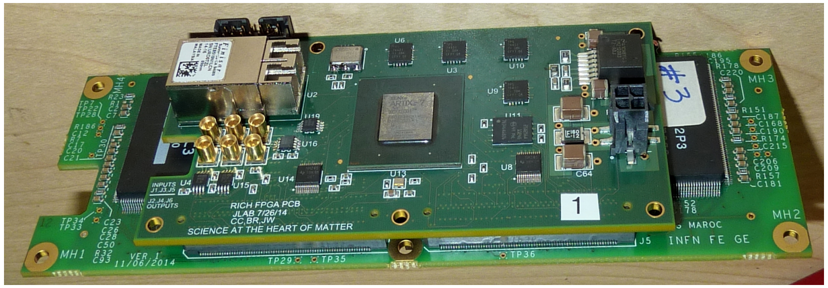
Test production
+ firmware
under validation

Front-End Electronics

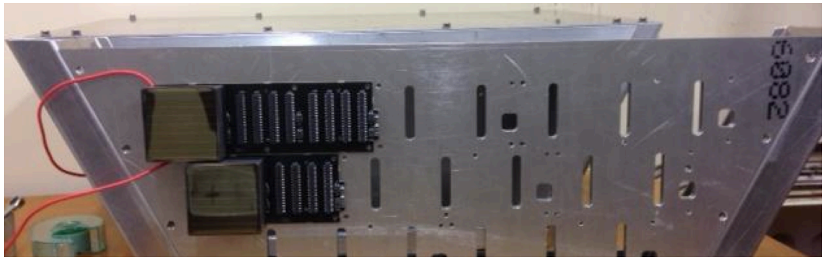




3 x ASIC BOARD (INFN) matching the

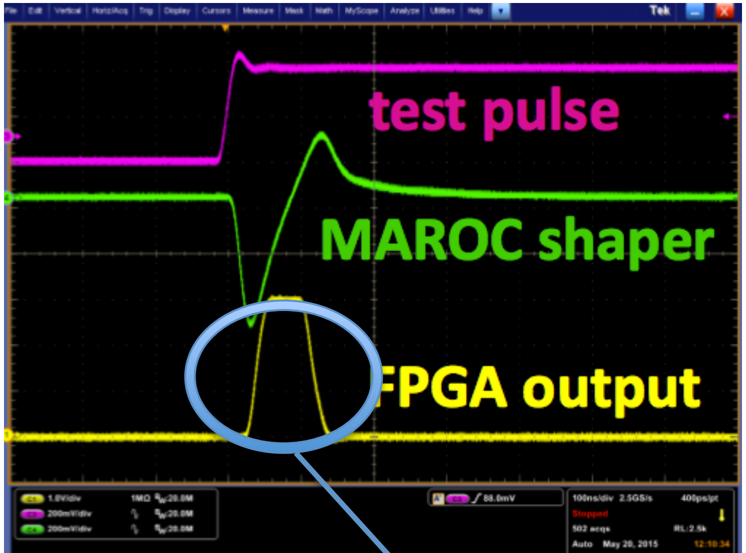


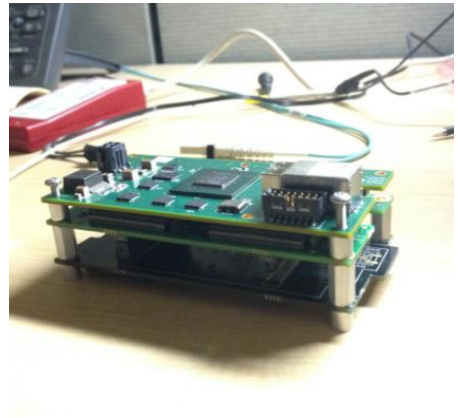
Universal FPGA BOARD (JLab)

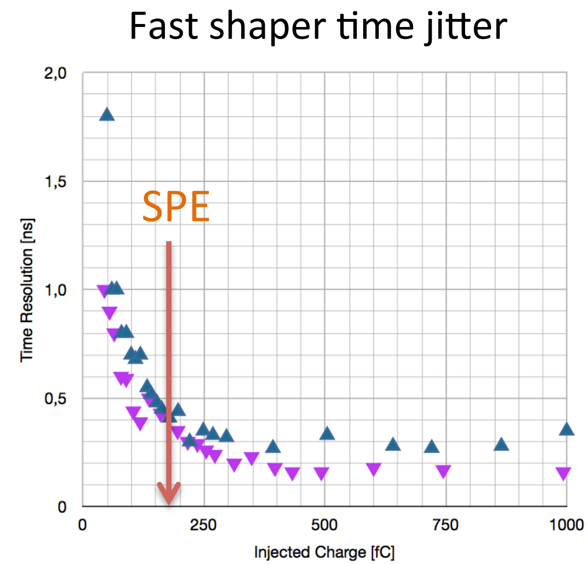


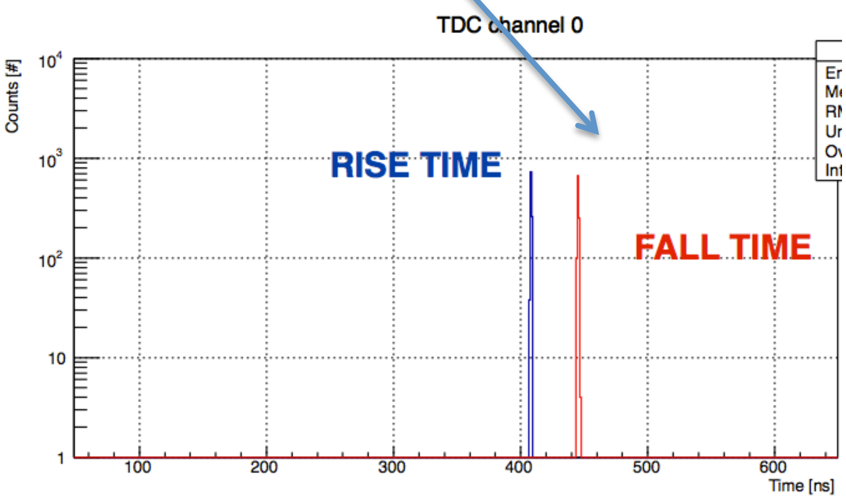
Assembling Tests

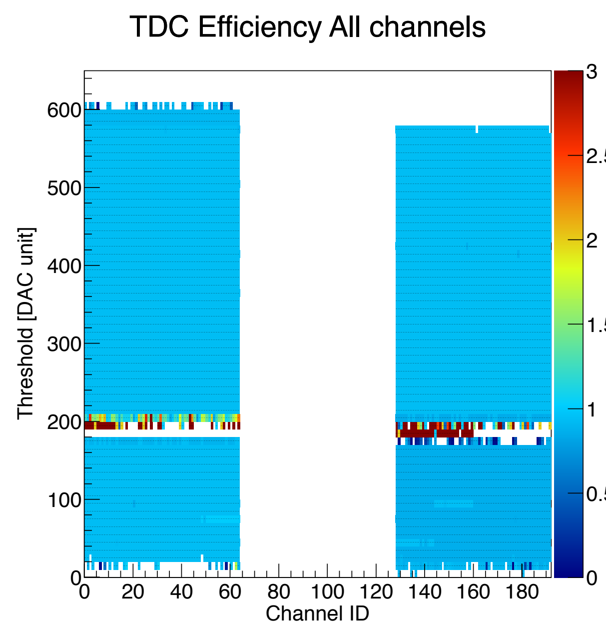
Front-End Electronics





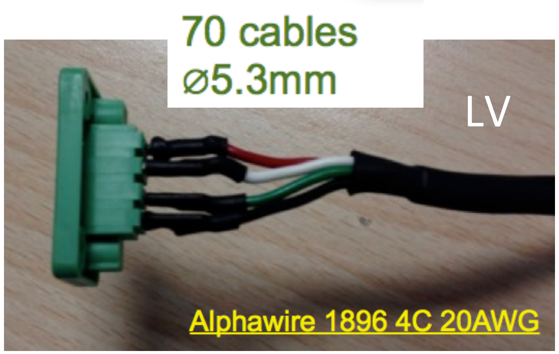






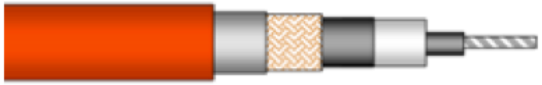
Electronics Services

LV & HV Power Supply
(compatible with EPICS)

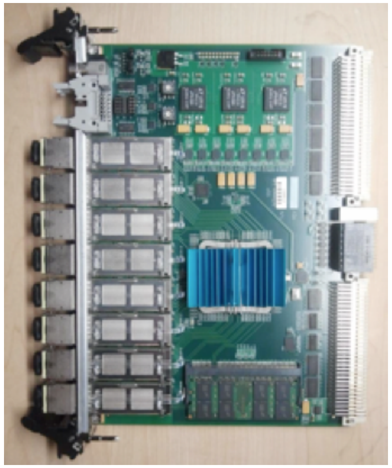


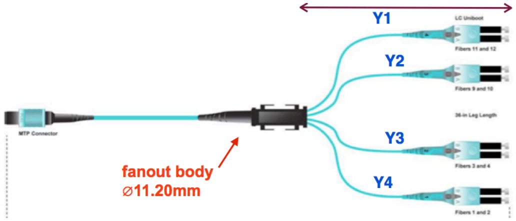
HTC-50-1-1
⌀3.2mm, 138 cables

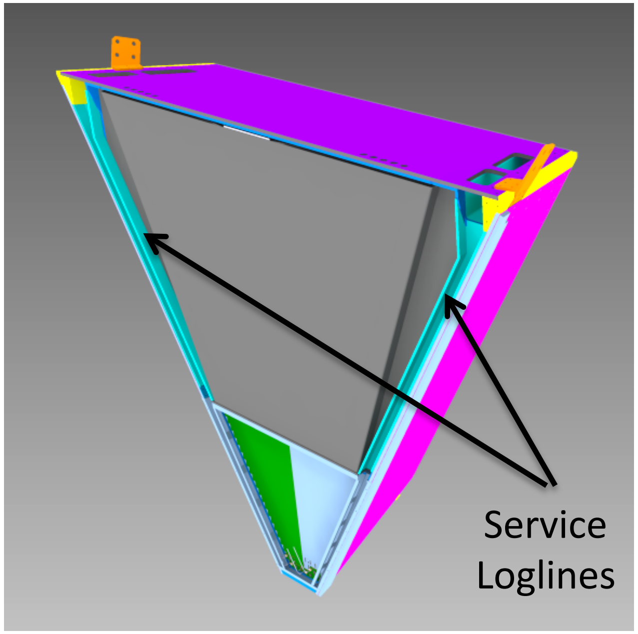
HV

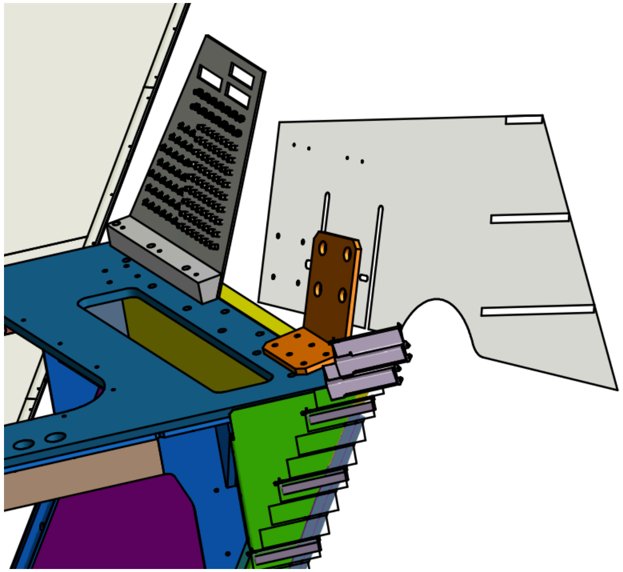


Fiber-Optic DAQ
(compatible with CLAS12)



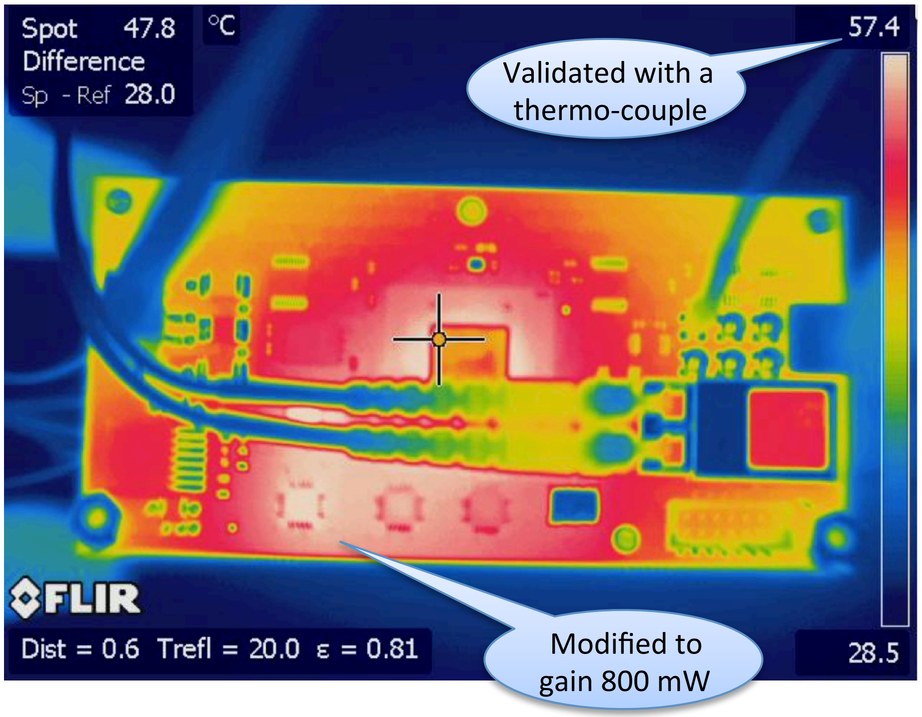




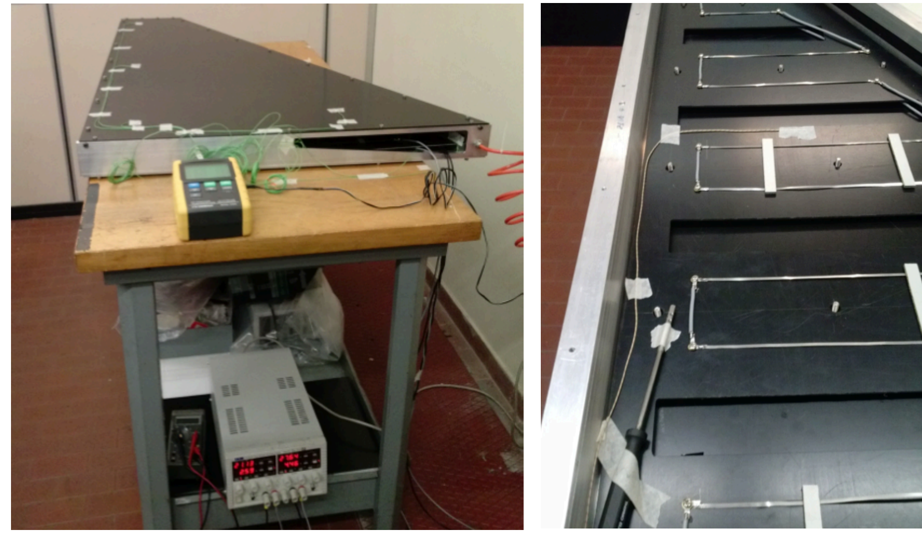


Front-End Electronics

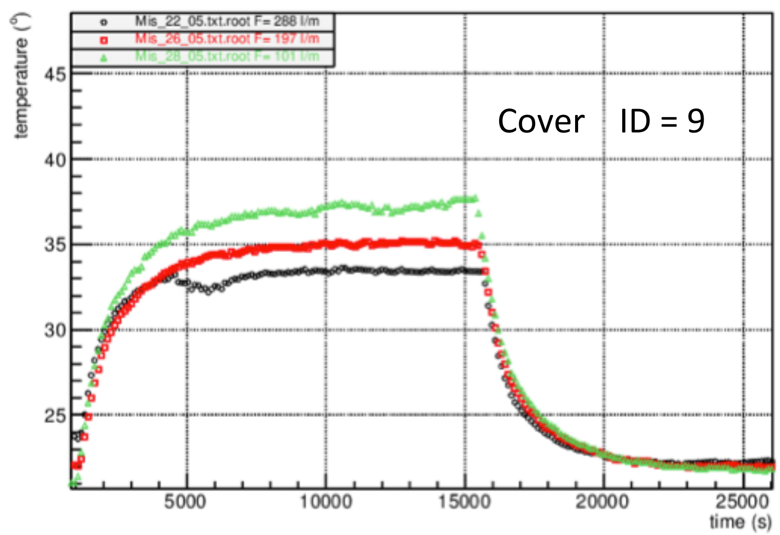
Tile power dissipation ~ 4 W



Cooling Tests ongoing in Frascati

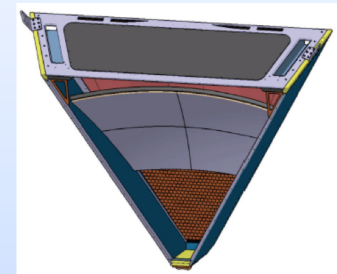


FTOF requirement: T < 100 F = 38 C



RICH Project: Mechanics

Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16



Reviewed by Jlab in June 2014

In production

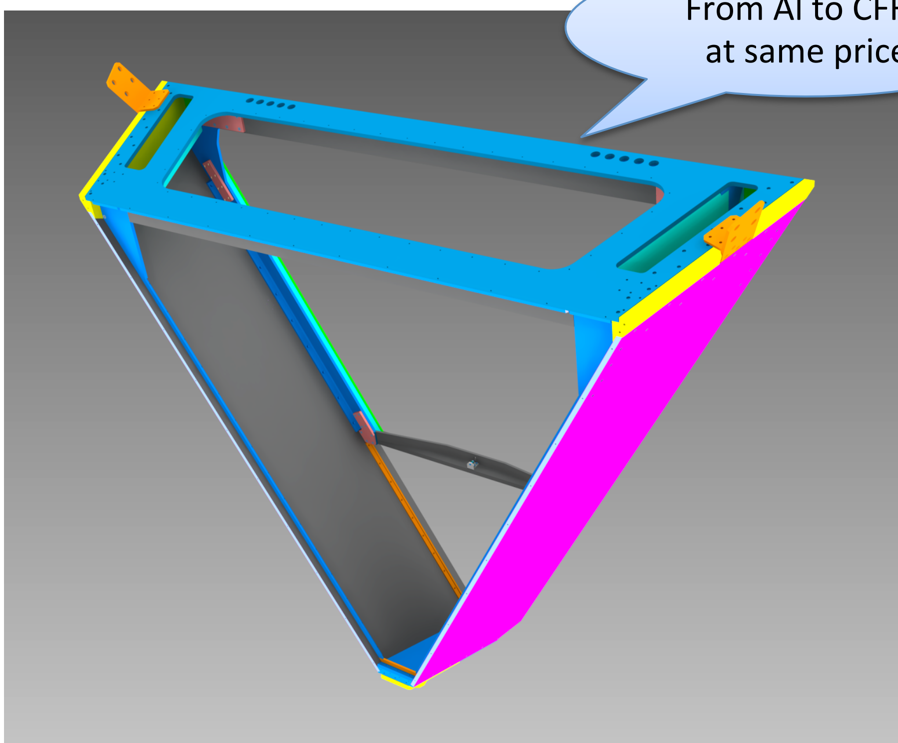
External Frame

Contract awarded to aerospace company TecnaVan Tecnologie Avanzate (Italy)
Delivery expected at the end of the year

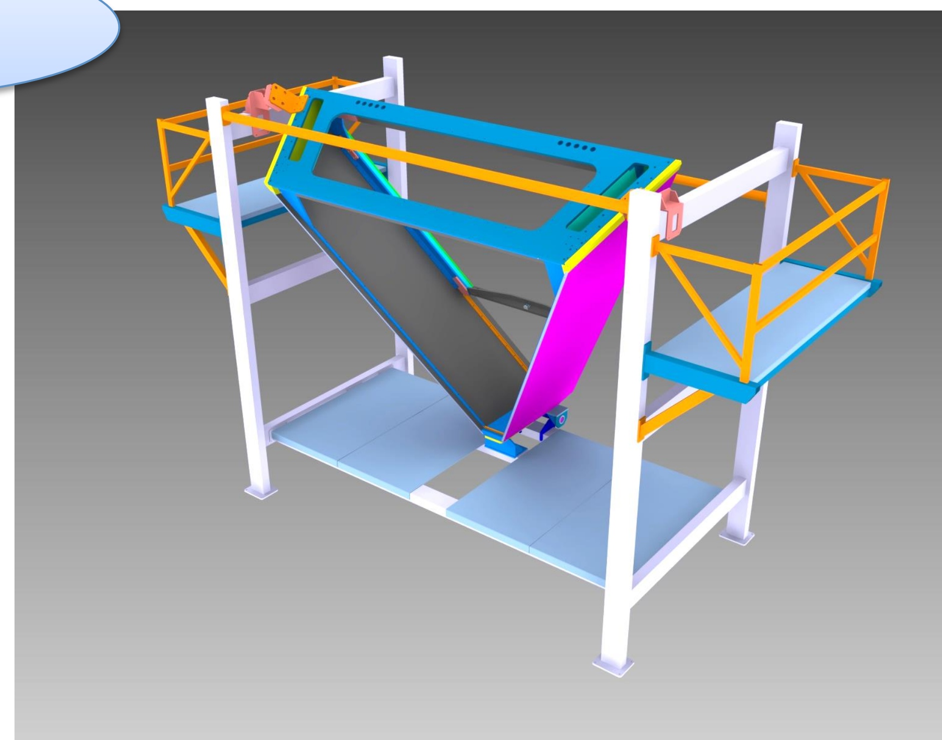
Specialized in large area, light and stiff composites for aeroplanes.

From Al to CFRP
at same price

RICH External Frame

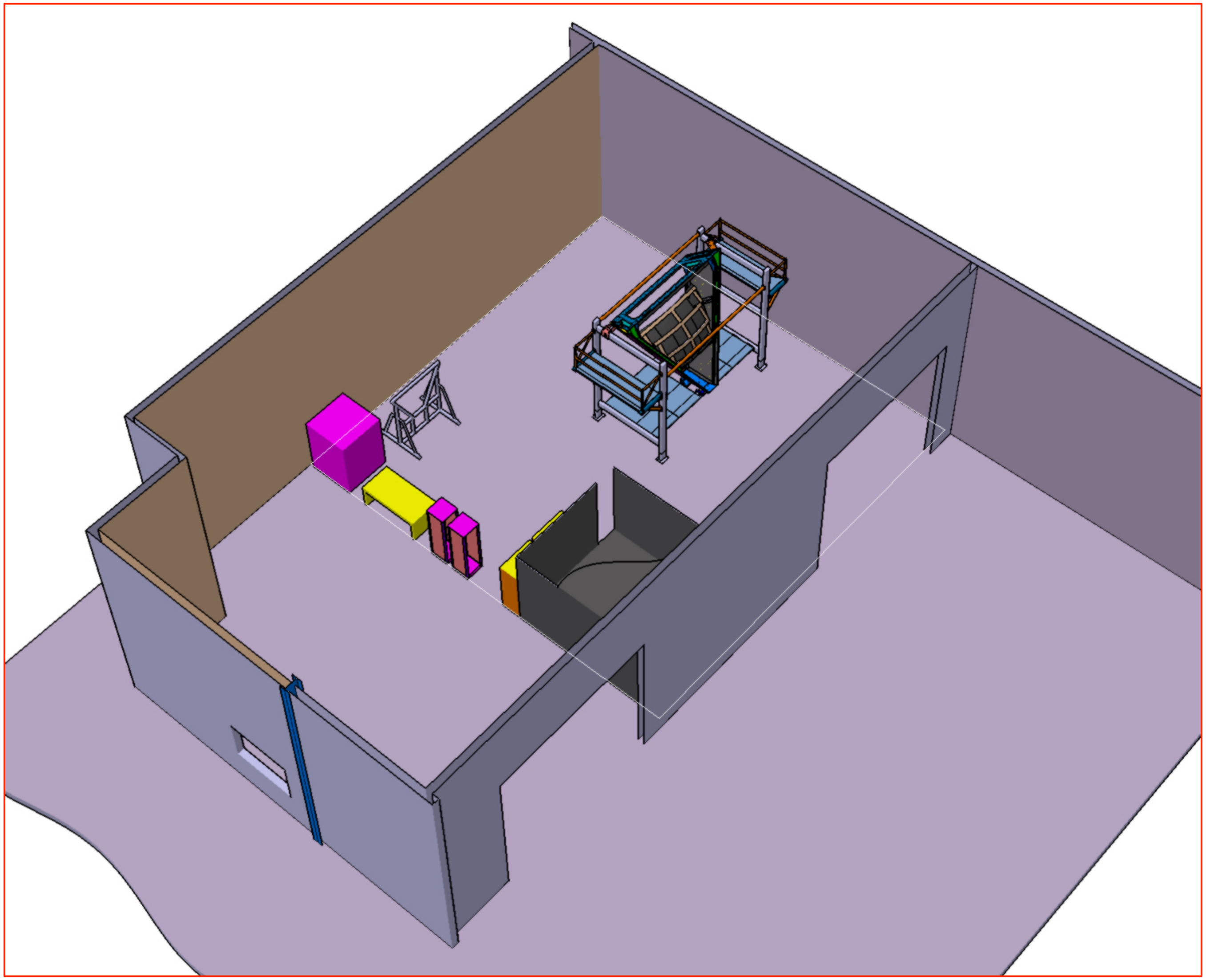


RICH Assembling Structure



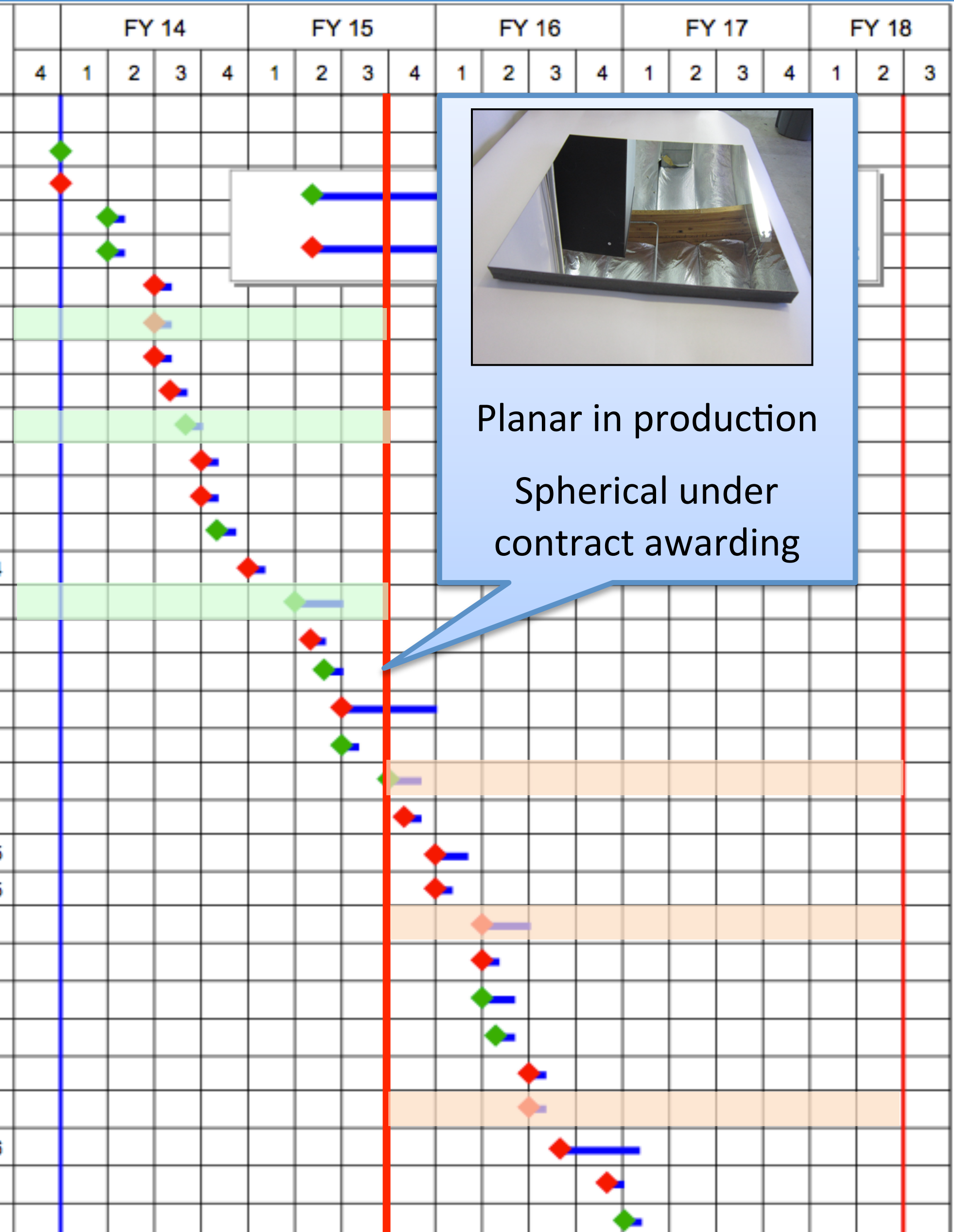
RICH Assembling

Assembly area in EEL124 available on October 2016



RICH Project: Mirrors

Activity Name	Date	MS Lvl	Finish Date
RICH Milestone Schedule			
Start of US Scope of RICH Project	9/30/13	1	9/30/13
PMT Contract Awarded	9/30/13	1	9/30/13
Start Aerogel Procurement	12/31/13	1	1/31/14
Start PMT Production	1/1/14	1	1/31/14
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2	4/30/14
Identification of Mirror Technical Specification	3/31/14	2	4/30/14
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2	4/30/14
First 20 PMT Delivery	4/30/14	2	5/30/14
Start Mirror Procurement	6/2/14	1	7/1/14
PMT First Delivery Acceptance Testing Completed	6/30/14	2	7/30/14
First 1 m2 Aerogel: Order for Procurement Submitted	6/30/14	2	7/30/14
Start Metallic External Frame Procurement	8/1/14	2	9/3/14
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2	10/30/14
Start Mirror Production	12/31/14	1	3/31/15
DAQ FPGA: Order for Procurement Submitted	1/30/15	2	2/27/15
FE Electronics: Order for Procurement Submitted	2/27/15	2	3/31/15
2 m2 Aerogel Production Completed	3/31/15	2	9/30/15
Start Electronic Panel Procurement	4/1/15	2	5/1/15
Start First Spherical Mirror Characterization	6/30/15	2	8/31/15
FE and DAQ FPGA Boards: Production Completed	7/30/15	1	8/31/15
2 m2 Aerogel Acceptance Tests Completed	9/30/15	2	11/30/15
External Frame & Electronic Panel Completed	10/1/15	2	10/30/15
Mirror Production Completed	12/31/15	1	3/31/16
PMT Production Completed	12/31/15	1	2/1/16
Start Mechanical Assembly Test	12/31/15	2	2/29/16
Start FE and DAQ Electronics Characterization	1/29/16	2	2/29/16
PMT Characterization Completed	3/31/16	2	4/29/16
Mechanical Assembly Survey of Spherical Mirrors Completed	3/31/16	2	4/29/16
3 cm Thickness Aerogel Production Completed	5/31/16	2	10/31/16
Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2	9/30/16
Start RICH Assembly	10/3/16	2	11/2/16



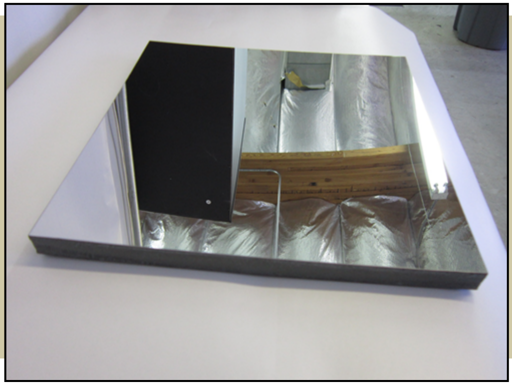
Planar in production

Spherical under contract awarding

Mirrors

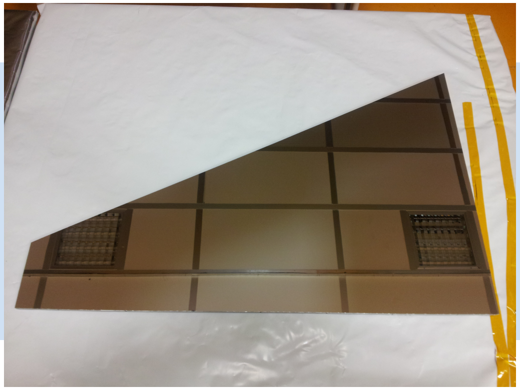
CFRP SPHERICAL Mirror

Radius tolerance <= 1%
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
D0 < 5 mm
Reflectivity > 90%



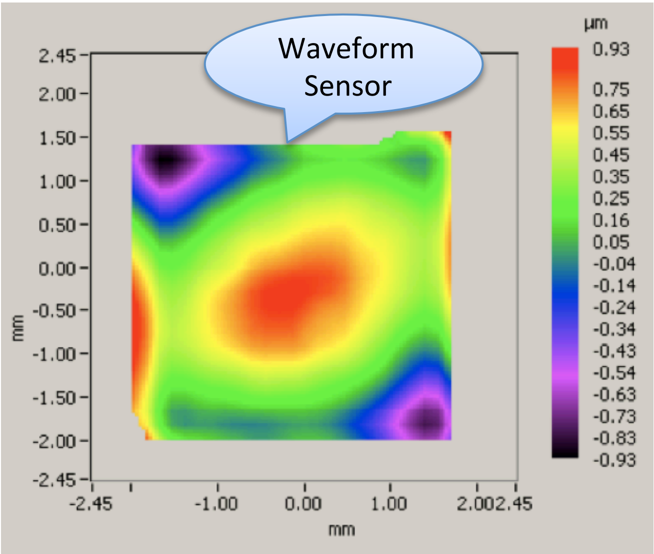
Planar Glass Mirror

Planarity tolerance <= 0.1 mm
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
Reflectivity > 90%

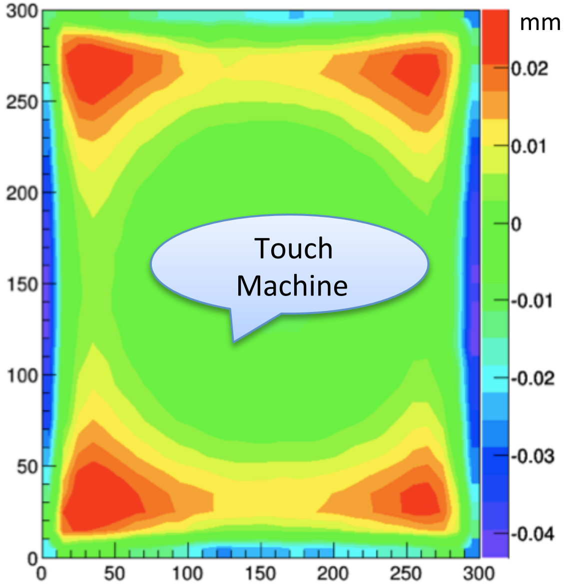


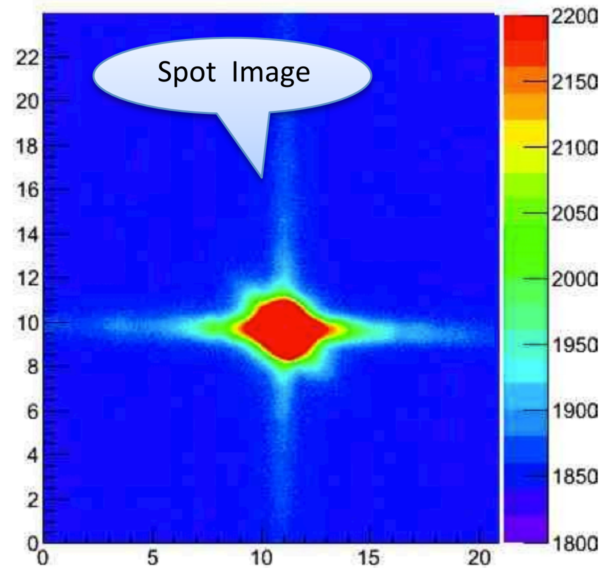
CFRP Spherical Mirror: Demo-1 Shape

CMA Report, April 2014

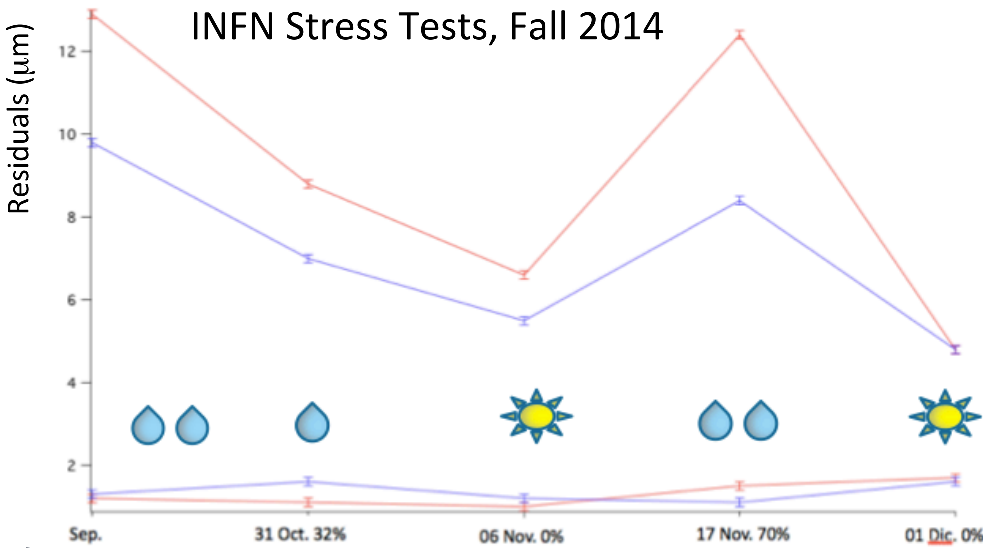


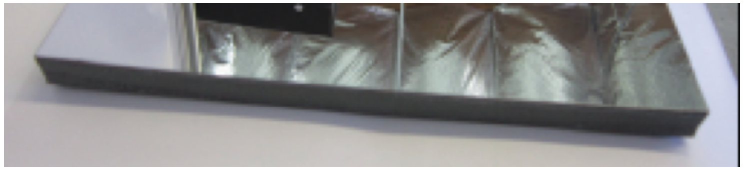
INFN Measurement, September 2014





INFN Stress Tests, Fall 2014

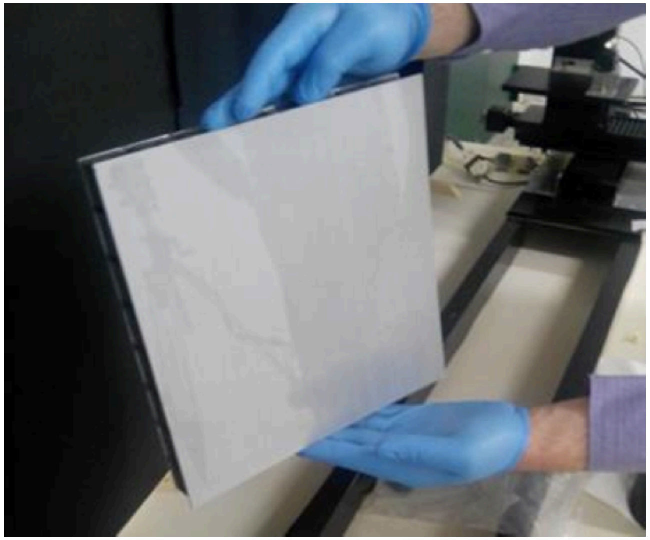


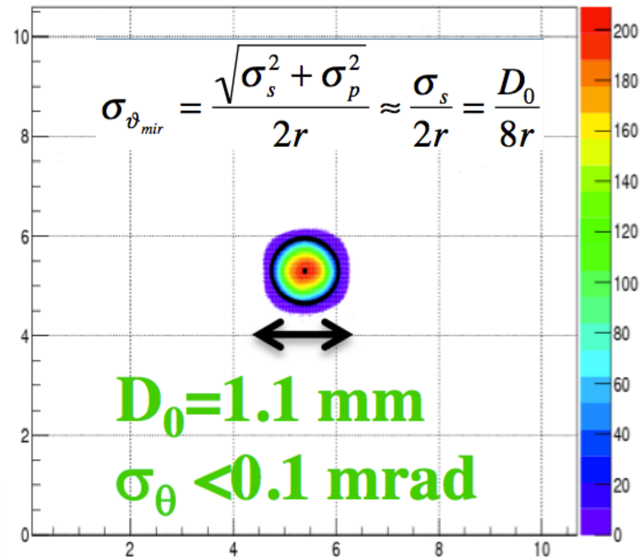


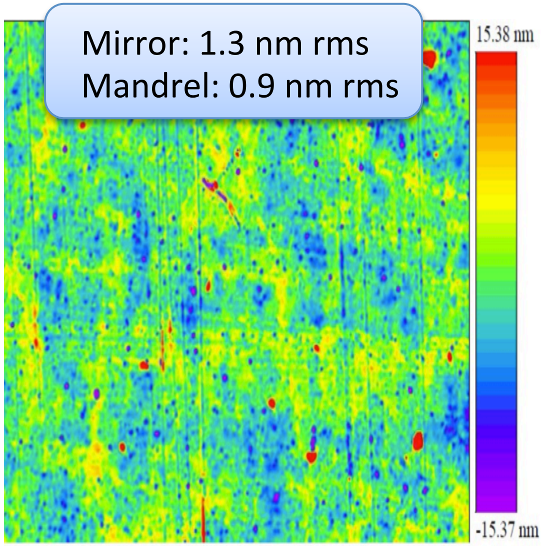
Foam core

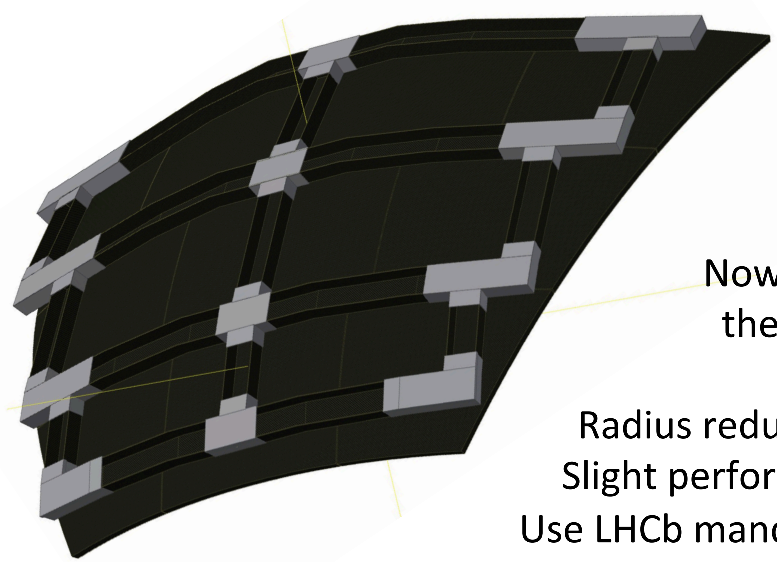
CFRP core

CFRP Spherical Mirror: Demo-2 OK



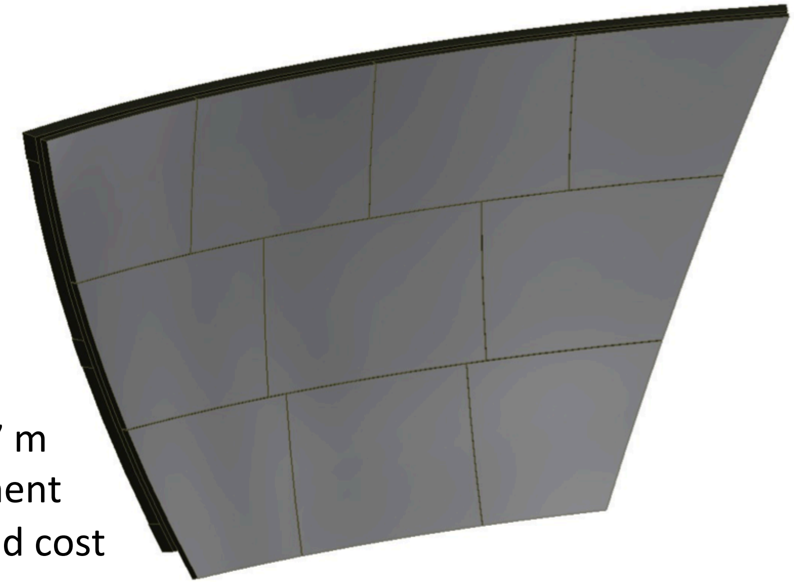






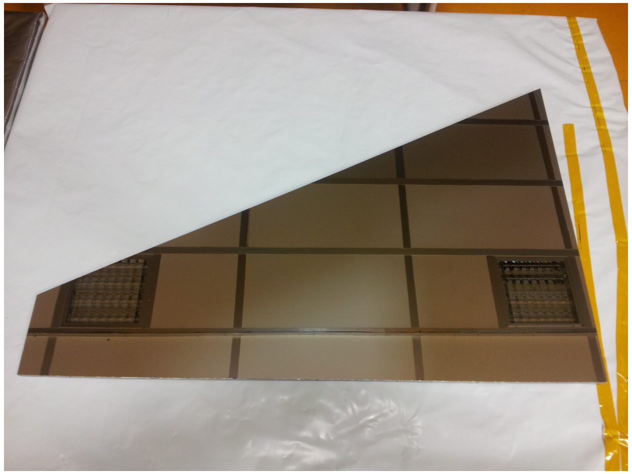
Now engineering the production

Radius reduced from 4 to 2.7 m
Slight performance improvement
Use LHCb mandrel: save time and cost

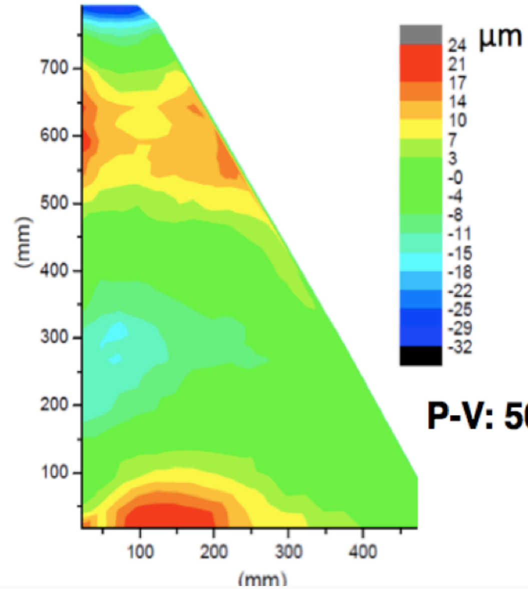


Glass-skin Planar Mirror

Demo delivered in spring 2014



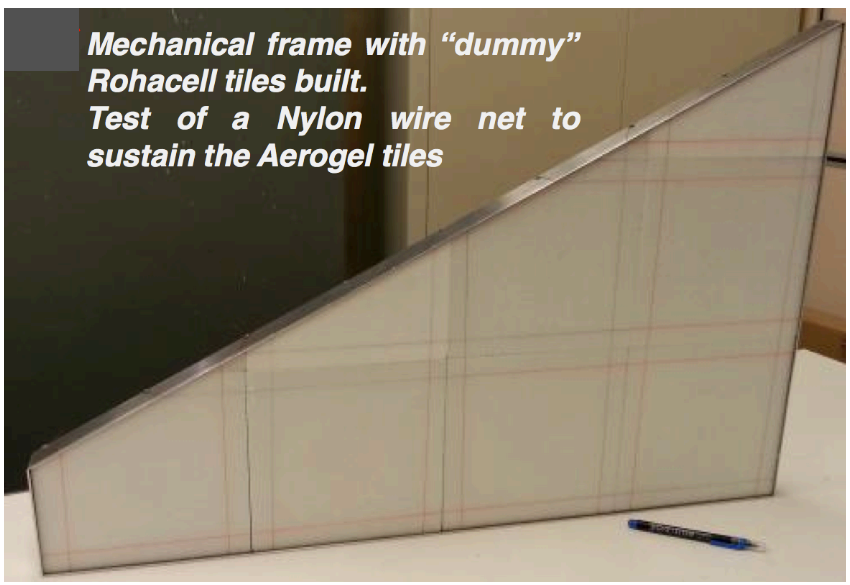
Production started in April 2014

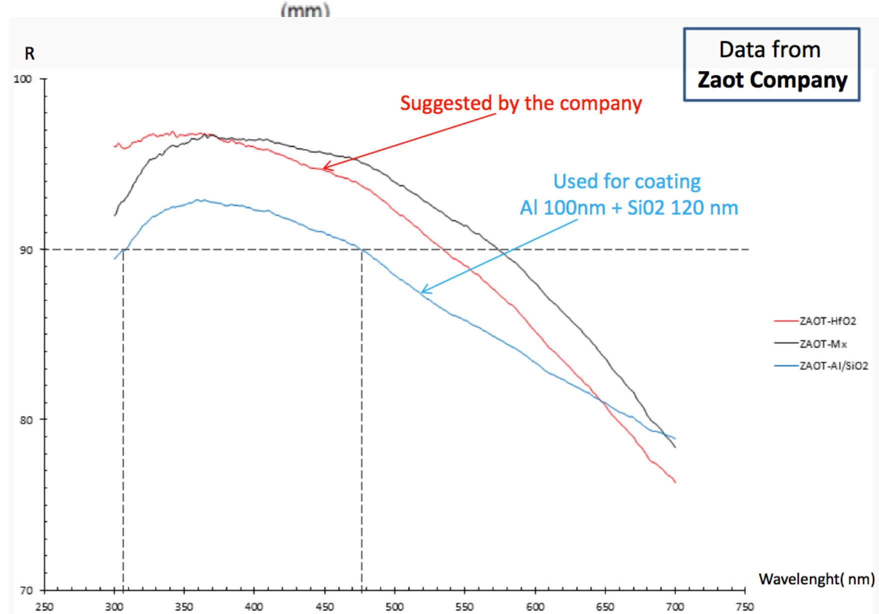


P-V: 50 μm

σ_θ **= 0.1 mrad**

Validation of aerogel holding scheme





CLAS12 RICH Project Midterm Status

- ✔ Mechanics
- ✔ Electronics
- ✔ Photodetector

  - In line or better vs the project

- ✔ Mirrors

  - Technological issue identified and overcame
  - Initial delay is being recovered

- ✔ Aerogel

  - Most critical part
  - Slow production start, should improve with time
  - Working to optimize specifications vs production efficiency